doideae encompasses ca. 190 genera (for more details see: "Tribal disposition of Periplocoideae and Asclepiadoideae genera," <http://www.uni-bayreuth.de/departments/planta2/>) and more than 2500 species. Relationships within this subfamily are most accurately represented by four tribes: the basal Fockeeae, the Marsdenieae, the Ceropegieae Orb. (this name replaces the up to recently used but younger name Stapelieae Decne.; cf. Endress & Bruyns, 2000), and the Asclepiadeae, which probably is the most advanced. The latter is subdivided into seven subtribes (sensu Liede, 1997, 2001 this volume).

Many studies have demonstrated the taxonomic value of chromosomal information in the plant kingdom in general (Stebbins, 1971; Lewis, 1980). In Asclepiadoideae, however, due to the dominance of $2n = 22$ and a "small" chromosome size, chromosomal data have been little used. Only rarely has karyology, in particular polypoidy, been utilized to support taxonomic conclusions or phylogenetic considerations (Meve, 1995a, 1997a). The study presented here is the result of a long-term project, which was initiated by the late G. Reese (Kiel), with chromosome counts for stapeliads (Reese, 1971; Reese & Kressel, 1967) and continued by us. A summary of the previous literature and a first overview were given by Albers (1983), and many of the further counts have been published in Albers (1974, 1975, 1976, 1977, 1981), Albers and Delfs (1983), Albers and Austmann (1987), and Albers et al. (1988, 1990). In the last 20 years we have emphasized karyotype length investigations in addition to the mere chromosome counts, and with the standard use of well-documented voucher material. We expanded the study to all tribes of the Asclepiadoideae (cf. Albers, 1983; Albers et al., 1993; Meve, 1999), as well as to Periplocoideae and Secamonoideae (Appendix 1). In addition, research included measurements of the DNA content (Huesmann, 1993).

Material and Methods

materials

The data gathered and used in this paper regarding Periplocoideae, Secamonoideae, and Asclepiadoideae are based mainly on our own investigations. Appendix 1 summarizes our recent findings and includes two types of data: first chromosome counts for taxa, which are unmarked, and counts confirming previous chromosome numbers, which are preceded by a hatch symbol (#). Where the same chromosome number was counted for different geographic regions, sometimes two different vouchers of a single taxon are given here. In addition, vouchers for chromosome measurements that are based on plants with already published chromosome numbers are included in Appendix 1. This material is marked by an asterisk (*). For the different calculations, we considered literature data as far as possible, except for information that was either unreliable or doubtful (e.g., for invalid and dubious taxa, presumably wrong counts, etc.). Chromosome numbers published without voucher provenance have been excluded as well, since the chance of including numbers being attributed to incorrectly determined plants increases considerably using undocumented material.

Information on Apocynoideae and Rauvolfioideae is mainly based on Van der Laan and Arends (1985). Information on Apocynaceae s.l. is supplemented by data extracted from Darlington and Wylie (1955), Fedorov (1974), and various volumes of the *Index to Plant Chromosome Numbers* edited by Ornduff (1967), Moore (1973, 1974, 1977), Goldblatt (1981, 1984, 1985, 1988), and Goldblatt and Johnson (1990, 1991, 1994, 1996, 1998).

methods

Chromosome numbers and chromosome sizes were established from adventitious root tip squash preparations. Ten mitotic metaphase plates from different root tips of each sample were investigated, though ten plates were not available in ca. one third of the samples due to the lack of actively growing root tips. The root tips were prepared as follows: pre-treatment in 0.002 M hydroxyquinoline for 4 hr. at 20°C (Tjio & Levan, 1950); fixation in Carnoy's solution for 24 hr. at 20°C; staining in carmine for 24 hr. at 60°C (Snow, 1963). For cytological investigation a Leitz Orthoplan microscope was used. The total lengths of all chromsomes in the genome were measured on maximally contracted chromosomes on the basis of camera lucida pencil drawings. Control (digital) measurements of the karyotype length were done by using the Leitz Orthoplan microscope in connection with a Leica Quantiment 500 (software QWIN). Measurements of the mean value, standard deviation, and error were part of the Leica program.

For fixations of Feulgen cytophotometric measurements of relative 2C DNA content Carnoy's solution was used (24 hr., 4°C) after pretreatment with 0.002M hydroxyquinoline for 4 hr.; ten fixed root tips from each taxon were hydrolyzed in 5M HCl for 80 min. at 20°C, washed in distilled water for 10 min., and stained in Feulgen reagent for 80 min. at room temperature. The washed root tips were

Table 1. Number and distribution of karyologically known species, subspecies, and varieties in Periplocoideae, Secamonoideae, and Asclepiadoideae (number of karyologically known genera in parentheses following the tribal names).

Chromosome number	PERIPLOCOIDEAE — (13)	SECAMONOIDEAE Secamoneae (1)	ASCLEPIADOIDEAE Fockeeae (2)	Marsdenieae (7)	Ceropegieae (37)	Asclepiadeae (41)
$2n = 18$						3
$2n = 20$						15
$2n = 22$	27	3	6	29	464	134
$2n = 24$					1	2
$2n = 26$						1
$2n = 28$						1
$2n = 40$						1
$2n = 44$	4	1			36	4
$2n = 66$					5	1
$2n =$ ca. 132					1	
$2n =$ ca. 154						1

incubated in 45% acetic acid for 10 min. Then only the dark-stained tips were squashed and the telophases (2C DNA content) were studied with the aid of a Zeiss scanning microscope photometer (SMP 05) using the two wavelength method published by Ornstein (1952) and Patau (1952), and the wavelengths λ max. = 575 nm and λ/2 = 510 nm as published by Greilhuber (1986). The DNA values were obtained on the basis of optical density. This was converted to pg according to Patau (1952). *Allium cepa* (2C DNA content = 33.5 pg [Bennett & Smith, 1976]) was taken as standard.

Results

Chromosome numbers

Karyological information for 672 species, representing ca. 24%, of the three subfamilies Asclepiadoideae, Periplocoideae, and Secamonoideae in 101 genera, representing ca. 44%, and belonging to 740 taxa altogether is summarized in Table 1. The chromosome numbers of 299 taxa are new to science and appear with locality data and vouchers in the compilation of Appendix 1 (unmarked), together with new counts confirming or completing earlier counts (preceded by #). For all counts, also including previously published chromosome numbers of both our and foreign counts, consult the expanded version of Appendix 1 under <http://www.uni-muenster.de/Biologie/botanik/AgAlbers.htm> or <http://www.uni-bayreuth.de/departments/planta2/>.

The basic chromosome number $x = 11$ is by far the most predominant number in Asclepiadoideae, Periplocoideae, and Secamonoideae (Table 1; Fig. 2); only ca. 3.5% of the studied species and taxa deviate from this. Among the deviant base numbers $x = 10$ (Fig. 3C) is the most frequent (ca. 2.5% of the studied species), followed by $x = 9$ (ca. 0.5% of the studied species), and the sporadic increasing deviates $x = 12$, 13, and 14 (Table 1).

In our analysis of the distribution of the basic chromosome number $x = 11$ in the asclepiad subfamilies, tribes, and subtribes neither the Periplocoideae nor the Secamonoideae contained any deviating numbers (Table 1, Fig. 2, Appendix 1). The same situation is found in the basal Asclepiadoideae tribes Fockeeae and Marsdenieae, the large Ceropegieae, and also in Asclepiadeae in the subtribes Gonolobineae, Asclepiadinae, and Tylophorinae (Table 1, Fig. 2, Appendix 1). All known deviating numbers are scattered among the three Asclepiadeae subtribes Astephaninae, Metastelminae, and Oxypetalineae (Table 1, Appendix 1). No taxonomic subunit above generic level is characterized by a basic number deviating from $x = 11$, but single genera like *Microloma* (Fig. 3C) and *Funastrum*, except *F. crispum* (cf. Appendix 1), share exclusively $x = 10$ chromosomes (Albers et al., 1993).

Polyploidy

In the Periplocoideae and Secamonoideae polyploidy occurs only as autoploidy, as simple doubling of $2n = 22$ (Table 1). These genomes with $2n = 44$ are only known from a few *Raphionacme* species (Fig. 2A), *Periploca visciformis*, and from one individual of *Secamone parviflora* (Appendix 1).

Approximately 6% of the species in the Asclepiadoideae are polyploids (Table 1). Polyploidy is

known to occur in 17 genera and is based on $x = 11$, except for the single determination of $2n = 40$ for *Tweedia brunonis* (Asclepiadeae, Oxypetalinae, Appendix 1). Some 85% of these polyploids are tetraploid ($2n = 44$) and 12% are hexaploid ($2n = 66$). The remaining instances of polyploidy include dodecaploidy ($2n = 132$) in the stapeliad *Caralluma burchardii* subsp. *burchardii* (Ceropegieae) (Meve, 1995a) and decatetraploidy in the twiner *Tylophora anomala* N. E. Br. (Asclepiadeae, Tylophorinae) (Meve, 1999). The latter taxon also includes the highest number ever found, $2n = 154$, in an isolated cytotype on Mt. Cameroon, whereas the frequent East African representative of this species is hexaploid with $2n = 66$ (Meve, 1999). The majority of polyploids are present in the tribe Ceropegieae, where 9.3% of the species (8.3% of the taxa) were found to be polyploid (Table 1, Fig. 3B). Stem-succulent stapeliad genera like *Duvalia*, *Orbea*, and *Stapelia* have especially high percentages of polyploid taxa (cf. Albers & Meve, 1991). The genus *Duvalia* in southern Africa, in particular, is a classic example of a polyploid complex including several tetraploids and two hexaploids, and contributes considerably to the understanding of phylogeny and biogeography of *Duvalia* and the African stapeliads in general since polyploidy is a uni-directional event (Meve, 1997a).

Infraspecific polyploidy is comparatively rare in the groups investigated. We did not find it in Periplocoideae, and only once in Secamonoideae (*Secamone parviflora*, Appendix 1). In Asclepiadoideae, especially Ceropegieae, it is less rare, but can be restricted to individuals (cf. *Huernia keniensis*, Appendix 1). Also, mixoploid individuals occur with single sections of the root tip meristem being polyploid instead of diploid (e.g., *Caralluma adscendens* var. *gracilis*: Fig. 3B, Appendix 1; cf. also Albers & Meve, 1991). In some cases the different levels characterize infraspecific taxa, e.g., in *Caralluma burchardii* (Meve, 1995a), *Duvalia sulcata* (Meve, 1997a), *Ceropegia racemosa*, and *Orbeopsis gerstneri* (Appendix 1), and in *Sarcostemma viminale*, where the subspecies *thunbergii* is a tetraploid (Liede & Meve, 1993) while the other seven subspecies are all diploid (Liede & Meve, 1995; Meve & Liede, 1996; Appendix 1).

CHROMOSOME MORPHOLOGY

Chromosomes of the groups under discussion are morphologically rather homogeneous. Chromosomes are typically (sub)metacentric, rarely acrocentric, and their karyograms offer very little variation. One pair of chromosomes per genome possessing secondary constrictions with satellites is the rule as shown in Figure 2A for *Raphionacme hirsuta*, and in Albers (1983: fig. 2a, p. 797) for *Brachystelma dinteri* Schltr. Heterochromatic regions, which have an affinity for Giemsa C-banding stain are consistently located on both sides of the centromere (Albers, 1983: fig. 2b, c) and are therefore of poor taxonomic value. However, the size of chromosomes varies considerably throughout the subfamilies and tribes studied (Figs. 1 and 2).

Single chromosome length varies from ca. 0.6 μm (sometimes less) to 1.7 μm (in rare cases more than 2.0 μm) comparing the tribes and subfamilies (Fig. 1). Within a single karyotype the chromosomes are comparatively similar in size. Only rarely were heterogeneous karyotypes found where chromosome sizes varied considerably (e.g., *Microloma incanum*: min. 0.68—max. 1.12 μm, Fig. 3C; *Heterostemma herberti*: min. 0.8—max. 1.4 μm, Meve, unpublished). In other cases, just one pair of chromosomes is ca. 30% larger than all the remaining, similarly smaller chromosomes (e.g., *Glossonema boveanum*, *Pentarrhinum insipidum*) (Appendix 1). The chromosomes of polyploid taxa are usually smaller than those of diploid ones. This behavior is repeated in infraspecific polyploid units, individuals, or mixoploid tissue.

Some general tendencies at subfamilial, tribal, and subtribal level can be recognized. However, it should be kept in mind that sample sizes vary considerably. This is so because most species are rarely collected at all, are difficult to transplant from the wild, and set seed only sporadically. Only species with succulent stems (stapeliads), tubers (e.g., *Raphionacme*), etc., are well represented in collections, whereas the majority of species in all three subfamilies are lianas or herbaceous vines without storage organs. Therefore, access to living material, especially taxa of the subfamily Periplocoideae and Secamonoideae (but also New World taxa), is restricted, and data concerning their chromosomes are in part rather limited despite all efforts made to obtain as much material as possible. As far as known, the average chromosome length in Periplocoideae differs between various genera. Whereas in *Periploca*, *Petopentia*, and *Stomatostemma* chromosomes are on the average about 1 μm long, those of *Raphionacme*, *Taccazea*, and *Schlechterella* (incl. *Triodoglossum*) are strikingly larger (ca. 1.5 μm; Fig. 1). The few chromosome sizes known for secamonoid taxa reach on the average 1.25 μm in length. This size is similar to that in some Periplocoideae. On the average, however, secamonoid chromosomes are slightly smaller (Fig. 1).

The large subfamily Asclepiadoideae comprises

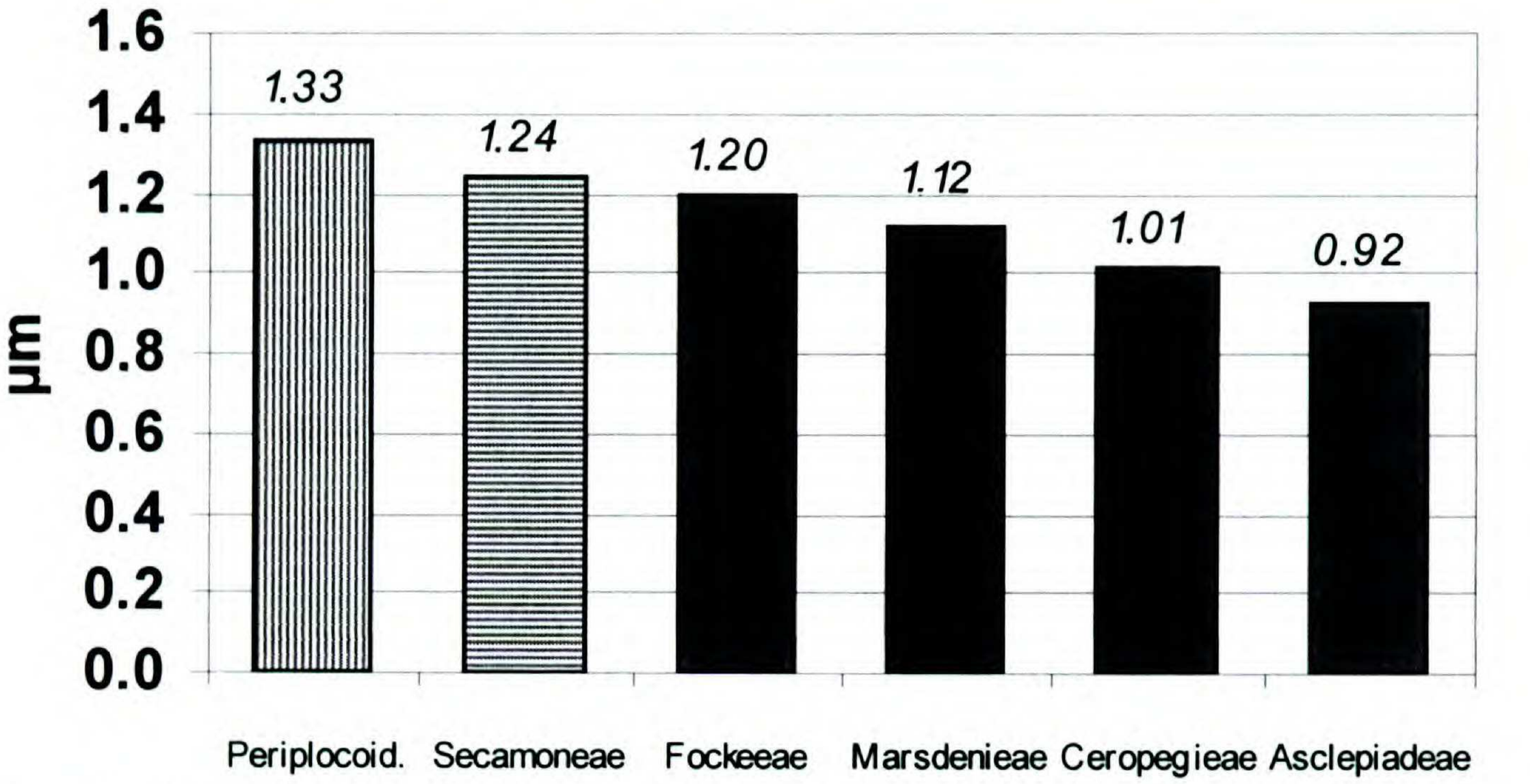


Figure 1. Average chromosome lengths in subfamily Periplocoideae (vertically striped column), Secamonoideae (horizontally striped column), and Asclepiadoideae (gray columns) with the four tribes Fockeeae, Marsdenieae, Ceropegieae, and Asclepiadeae. The ranges are in Periplocoideae: $\bar{x}$ (min. 1.06 µm [*Stomatostemma*]—max. 1.61 µm [*Raphionacme*]), number of samples: 12; Secamonoideae: $\bar{x}$ (min. 1.13 µm—max. 1.34 µm), number of samples: 3 *Secamone*; Fockeeae: $\bar{x}$ (min. 1.15 µm [*Cibirhiza*]—max. 1.27 µm [*Fockea*]), number of samples: 3; Marsdenieae: $\bar{x}$ (min. 0.91 µm [*Hoya*]—max. 1.44 µm [*Telosma*]), number of samples: 17; Ceropegieae: $\bar{x}$ (min. 0.68 µm [*Duvaliandra*]—max. 1.72 µm [*Neoschumannia*]), number of samples: 176; Asclepiadeae: $\bar{x}$ (min. 0.74 µm [*Philibertia*]—max. 1.15 µm [*Gomphocarpus*]), number of samples: 55.

the four tribes Fockeeae, Marsdenieae, Ceropegieae, and Asclepiadeae. The Gonolobeae, which were earlier considered to be a tribe of their own, were transferred by Liede (1997) as subtribe Gonolobinae to the Asclepiadeae. The chromosomes of the Fockeeae have an average length of 1.20 µm, which is not much shorter than in the Secamonoideae (1.24 µm, Fig. 1). The chromosome lengths in the remaining tribes are on average smaller, being 1.12 µm in Marsdenieae, 1.01 µm in Ceropegieae, and 0.92 µm in Asclepiadeae (Fig. 1). The situation in the tribe Marsdenieae is similar to the two groups presented above: parts of the genera *Telosma* and *Marsdenia* have rather large chromosomes (ca. 1.4 µm on the average, but just 1.12 µm in the depicted *Telosma accedens*, Fig. 2D), while all other marsdeniads investigated have smaller chromosomes around 1 µm. The best studied group is the tribe Ceropegieae, where the stem-succulent representatives such as *Caralluma*, *Huernia*, *Orbea*, *Stapelia*, etc., the "stapeliads," represent the main stock of species (ca. 350), followed by *Ceropegia* (180) and *Brachystelma* (ca. 100 species). Almost 90% of the stapeliad species and infraspecific taxa are karyologically known, the best characterized group in the family. The smaller genera such as *Hoodia*, *Stapelianthus*, or *Tridentea* are usually rather homogeneous as to chromosome size, but as the size of the genera increases, variation proportionally increases in some genera. For example, in the large genus *Ceropegia*, the average chromosome length varies between 0.8 µm (*C. occidentalis*) and ca. 1.5 µm (*C. rupicola*; Meve & Albers, unpublished). A similiar pattern is found in *Brachystelma* with averages of 0.78 µm in *B. filifolia* and 1.48 µm in *B. burchellii* (Meve & Liede, 2001a). Chromosomes in most species and genera of the Ceropegieae, however, have an average length of around 1 µm (Fig. 1). Noteworthy outliers at the lower end are the genera *Duvaliandra* and *Leptadenia*. In the monotypic stapeliad genus *Duvaliandra* conspicuously small chromosomes (0.68 µm) were found. In *Leptadenia* (two species investigated, cf. Appendix 1), the average length is 0.72 µm (Meve & Albers, unpublished). Relatively large chromosome sizes are found in species expressing evolutionarily basic morphological characters (*Caralluma edulis*, *C. sinaica* [1.40 µm, Huesmann, 1993], *Ceropegia sankuruensis* [1.37 µm; Meve, unpublished]). The largest chromosomes of the whole tribe (1.72 µm on the average) were observed in *Neoschumannia kamerunensis* (Meve, 1997b). This strong twiner is isolated from all other species of the tribe by its 3-seriate corona. Meve (1995b) considered *Neoschumannia* to be primitive in the Ceropegieae based on morphological characters. With-

in the Ceropegieae, genera with a twining, non-succulent habit, such as *Heterostemma*, *Leptadenia*, or *Orthanthera*, form a heterogeneous assemblage around the stapeliads and their relatives such as *Brachystelma* and *Ceropegia*. In contrast to *Ceropegia* and the stapeliads, chromosomes in *Heterostemma*, *Leptadenia*, and *Orthanthera* are on average ca. 0.25 μm smaller.

The smallest chromosomes, however, are found in the Asclepiadeae (Fig. 1), in particular the subtribes Asclepiadinae, Astephaninae, Metastelminae, and Oxypetalinae (ranging from 0.7 to 1.15 μm on the average). Usually, their chromosomes are less than 1 μm long. Only in one subtribe of the Asclepiadeae, the Gonolobinae, are chromosomes on the average larger than 1.05 μm.

Comparing average chromosome lengths in the three subfamilies as well as those for the tribes of the Asclepiadoideae, a general tendency of size reduction can be seen (Figs. 1, 2). Stepwise, starting with the presumably most primitive subfamily Periplocoideae to the higher evolved Asclepiadoideae, and within the latter subfamily starting with the most primitive Fockeeae to the most advanced Asclepiadeae, a decrease in chromosome size has taken place (Fig. 1). Chromosome size evolution recurs in a similar pattern within lower units such as subtribes or groups of related genera as such as the stapeliads.

2C DNA VALUES

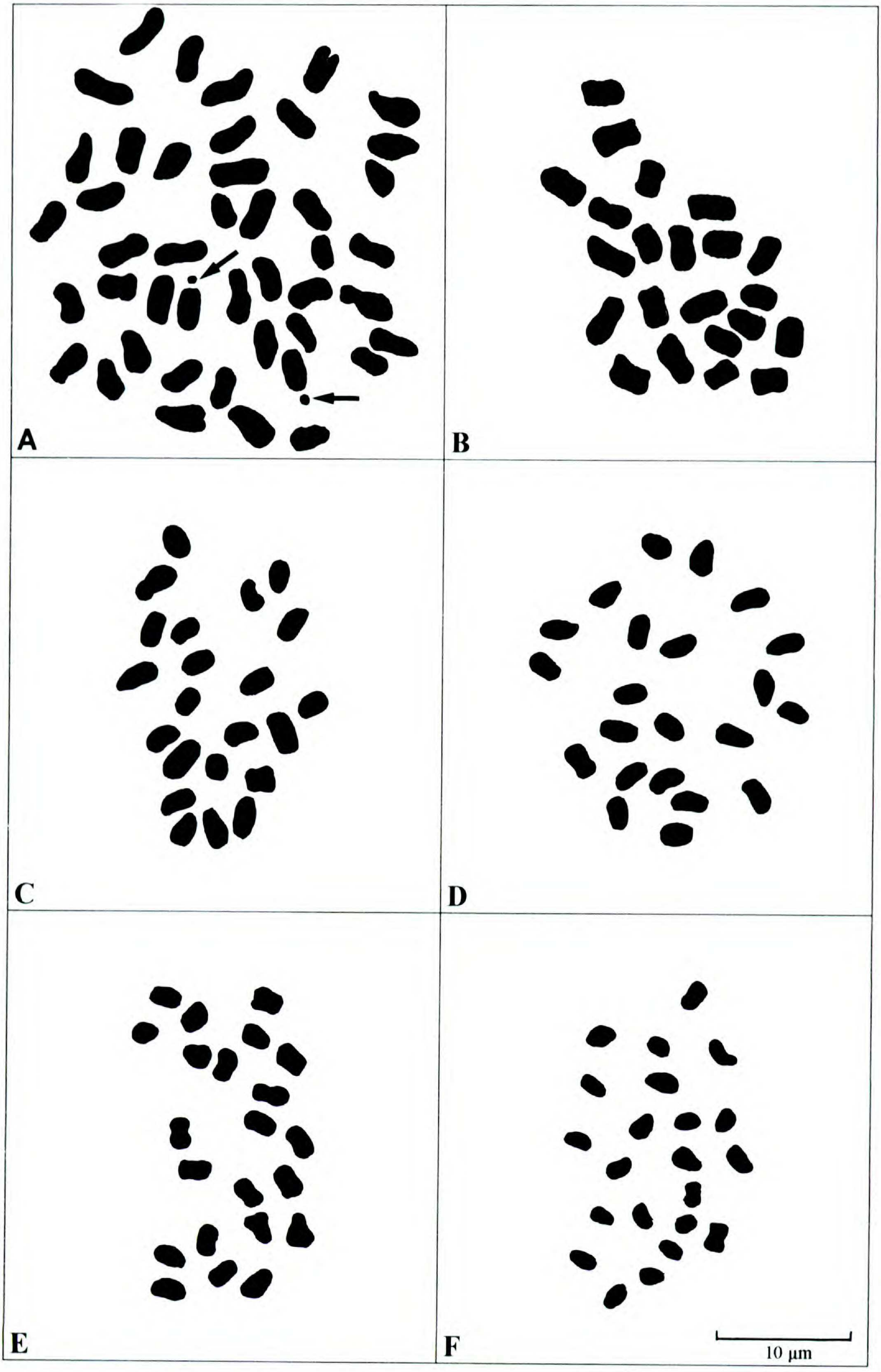
The relative 2C DNA values for over 30 taxa of *Caralluma*, *Ceropegia*, *Duvalia*, *Orbea*, *Stapelianthus*, and *Tridentea* have been cytophotometrically determined in our lab and compared to the average karyotype lengths (cf. Huesmann, 1993). All our studies showed a good correlation between the two parameters of DNA content and chromosome size. For example, in the *Caralluma* complex we found for *C. umbellata* 0.82 pg/20.4 μm, *C. diffusa* 1.18 pg/27.6 μm, *C. europaea* 1.38 pg/33.7 μm, *C. sarkariae* 1.43 pg/18.9 μm, *C. turneri* 1.50 pg/24.3 μm, and for *C. edulis* 1.83 pg/27.8 μm (Huesmann, 1993). The differences between some of these values are considerable, supporting, for example, the separation of *Caralluma* s.l. into a handful of smaller genera as will be proposed by Meve and Liede (unpublished) based on DNA sequence data. Determinations of 4C DNA values, as investigated by Pattnaik et al. (1997) for six stapeliad species, were not studied by us. Whereas the karyotype lengths measured by these authors are in the range of our results, the DNA values estimated are by far higher than ours. The reasons for these deviations are unclear.

GEOGRAPHICAL DISTRIBUTION OF DIFFERENT BASIC CHROMOSOME NUMBERS

We have contributed most to the karyological knowledge in African Asclepiadoideae since the emphasis of our ongoing study was on the Ceropegieae. In contrast, in other regions of the world there are still many gaps in the data. Despite this geographically biased data set of basic chromosome numbers, some summary can be made to show their diversity in the different regions of the world (Table 2).

The Asclepiadoideae are worldwide in distribution, whereas the primitive Periplocoideae and Secamonoideae are restricted to the Old World. Notably, all taxa investigated of the latter two subfamilies, and also the basal Fockeeae of the Asclepiadoideae, have $x = 11$, large chromosomes, and they all come from Africa (only one species from Arabia).

In Europe, Madagascar, and Australia only the basic number $x = 11$ is known. In the best studied area, Africa, just a single genus, the southern African *Microloma*, has the deviating basic chromosome number of $x = 10$ (Albers et al., 1993). The African *Pentarrhinum insipidum* is variable in its basic chromosome number ($x = 9$, 11, and 12), although the $2n = 18$ reported from Burundi (Renard et al., 1983) remains mysterious because otherwise only increased numbers have been found for this species. Additionally, $x = 13$ has been counted once by Bramwell et al. (1972) for *Calotropis procera* from the Cape Verde Islands, whereas Borgen (1975) confirmed the counts of $x = 11$ found also by other authors (e.g., Bhattacharya et al., 1971). We also counted $x = 11$ for the same taxon and even from Cape Verde. In all cases where counts of $2n = 24$ have been found, 2 B-chromosomes are most likely responsible, due to their inconsistency of occurrence; variation between $2n = 22$ and $2n = 24$ occurs among populations (*Pentarrhinum insipidum*) and also within populations (e.g., *Brachystelma mortonii*, Appendix 1) corroborating this concept (cf. Rees, 1974). One or two B-chromosomes have been found to occur commonly in *Hoya* (Nakamura, 1993). In Asia the percentage of species with deviating numbers ($x = 12$ have been reported for, e.g., *Heterostemma tanjorense* Wight & Arn. [Navaneetham, 1981] or *Tylophora asthmatica* Wight & Arn. [Sreedevi & Namboodiri, 1977]), is slightly higher than in the rest of the Old World, but strikingly different from the situation found in


A
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10 µm

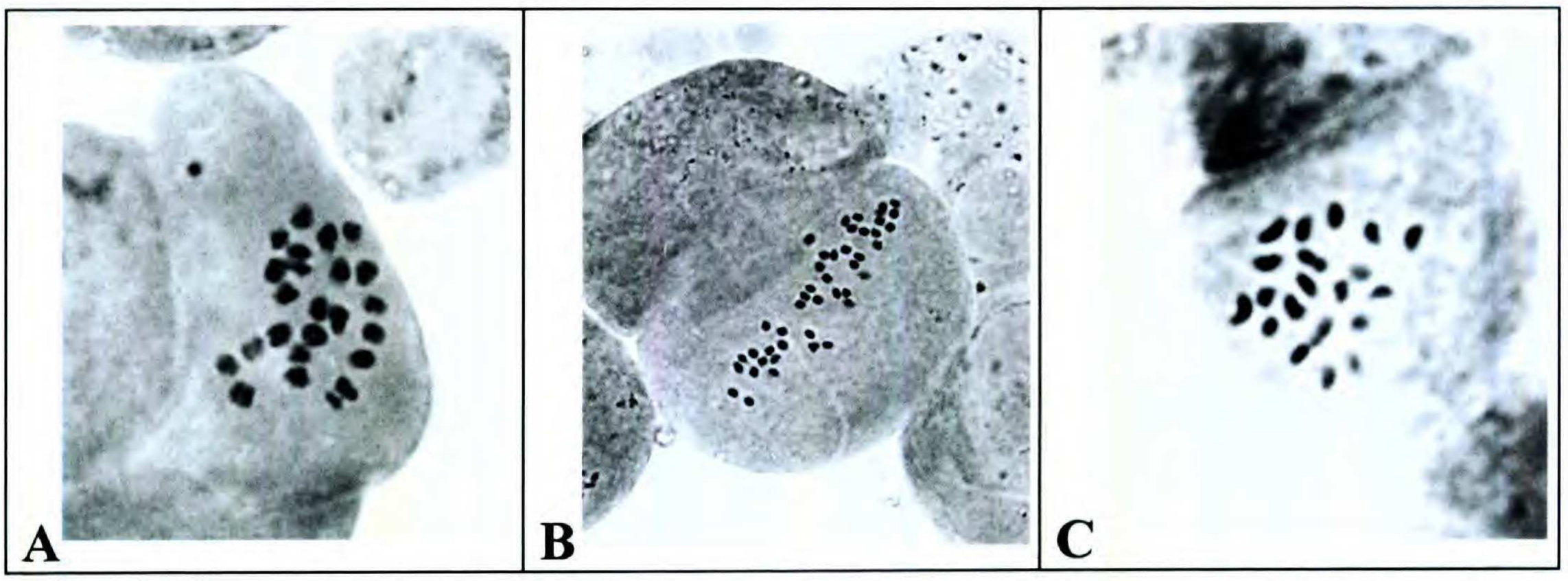

Figure 3. Mitotic metaphase chromosomes of Asclepiadoideae in the light microscope. —A. *Ceropegia cumingiana*, $2n = 22$ (*Liede 3250*). —B. *Caralluma adscendens* var. *gracilis*, $2n = 44$ (*Sarkaria 32-90*). —C. *Microloma incanum*, $2n = 20$ (*Albers & Meve 88*). (A: ca. 1350×; B: ca. 500×; C: ca. 2400×; for vouchers see Appendix 1.)

the New World (Table 2). Here, one fifth of the species in North America (incl. Mexico) and more than one third in southern Central and South America have derived, predominantly decreased numbers (e.g., *Grisebachiella*, *Orthosia*, *Philibertia*; Appendix 1). It seems that chromosomal evolution with respect to the basic numbers has begun a new stage in the New World.

Discussion

Different basic chromosome numbers often discriminate a taxon into separate taxonomical subunits such as families, tribes, or genera (various examples are given in Stace, 1989). Many studies have demonstrated the taxonomic value of basic chromosome numbers even at infrageneric level (e.g., *Pelargonium*: Albers et al., 1992; *Moraea*: Goldblatt, 1971, 1986). As van der Laan and Arends (1985) indicated, the basic number $x = 11$ is the most frequent number in Apocynaceae s. str. (Apocynoideae & Rauvolfioideae). Approximately 60% of the species they studied have this number, but 40% deviate (van der Laan & Arends, 1985). The numbers $x = 10$, 9, 8, 7, and 6 have evolved by descending aneuploidy, whereas $x = 12$ is an increasing number (van der Laan & Arends, 1985). One fifth of all studied species contain the deviating number $x = 9$. This high proportion might be inflated by the relatively high number of karyologically studied species in the genera *Pachypodium* and *Strophanthus*. At present karyological information is only available for 241 species (14%) of Apocynaceae s. str. from 73 genera (40%) (van der Laan & Arends, 1985; Albers, unpublished data). Although this rate seems rather poor, it represents quite a typical situation for a family with predominantly woody species (e.g., Ehrendorfer, 1982).

The only basic chromosome number in the Periplocoideae and Secamonoideae is $x = 11$, which is also by far the most common situation in the Asclepiadoideae. Comparing these basic chromosome numbers with those of the Apocynaceae s. str. there is one striking difference: deviating basic chromosome numbers occur much less frequently in Asclepiadoideae with only about 4% compared with 40% in the other two subfamilies Apocynoideae and Rauvolfioideae.

The relatively frequent occurrence of different basic numbers in various tribes and subtribes of both Apocynoideae and Rauvolfioideae points to parallel genome evolution (van der Laan & Arends, 1985). The main developments have taken place repeatedly but independently.

In Apocynaceae s. str. polyploidy is only known to occur in nine genera (van der Laan & Arends, 1985). In total, 13% of the Apocynaceae s. str. are

←

Figure 2. Squash preparations of mitotic metaphase plates (camera lucida drawings). —A. Periplocoideae: *Raphionacme hirsuta* ($2n = 44$, two satellites marked by arrows, *Venter 9110*). —B. Secamonoideae: *Secamone punctulata* ($2n = 22$, *Hemp s.n.*). —C. Asclepiadoideae, Fockeeae: *Cibirhiza dhofarensis* ($2n = 22$, *Butler s.n.*). —D. Asclepiadoideae, Marsdenieae: *Telosma accedens* ($2n = 22$, *Schneidt 96-45*). —E. Asclepiadoideae, Ceropegieae: *Angolluma denboefii* ($2n = 22$, *Masinde 889*). —F. Asclepiadoideae, Asclepiadinae: *Sarcostemma viminale* subsp. *odontolepis* ($2n = 22$, *Meve & Liede 3354*). (Bar = 10 μm; for vouchers see Appendix 1.)

Table 2. Geographical distribution of basic chromosome numbers in Periplocoideae, Secamonoideae, and Asclepiadoideae (Apocynaceae).

Region	No. of taxa[1] studied	Basic chromosome numbers of karyologically known taxa in percentages					
		x = 9	x = 10	x = 11	x = 12	x = 13	x = 14
Old World							
Africa & Arabia	496	0.2	0.8	98.6	0.2	0.2	—
Europe	9	—	—	100	—	—	—
Asia	83	—	—	95.2	4.8	—	—
Australia	9	—	—	100	—	—	—
Madagascar	63	—	—	100	—	—	—
New World							
North America incl. Mexico	37	—	18.9	81.1	—	—	—
S Central & South America	30	10	23.3	63.4	—	—	3.3

[1] Each taxon is scored in every region of its occurrence.

polyploids, which is comparatively little (cf. Morton, 1966). All basic chromosome numbers are involved in different polyploid series. The highest number ever counted are the ca. 180 chromosomes of *Alyxia* (van der Laan & Arends, 1985). The situation in Asclepiadoideae is very similar, but the degree of polyploids is even lower, with only around 6%. Only in the Ceropegieae, which are dominated by the stem-succulent stapeliads, does polyploidy increase to about 10%, supporting the old hypothesis of the better ability of polyploids at colonizing new areas and being more hardy in less favorable habitats (e.g., Stebbins, 1985). However, compared to the 27.9% polyploid taxa in Cactaceae (Pinkava et al., 1985), it cannot be argued that polyploidy really played an important role in stapeliad evolutionary history. This might be true only on a more regional scale. The stapeliads had their evolutionary center in northeastern Africa (Meve, 1997a), but they formed a secondary center in southern Africa, where the majority of stapeliad polyploids are distributed (Albers, 1983; Albers & Meve, 1991, unpublished data). Here, rapid speciation took place accompanied not by derivation of chromosome number but instead by an increase in polyploidization events. This means that speciation here has taken place only at the level of chromosome and not of the karyotype (genome evolution). In contrast, the Apocynaceae s. str. have been more successful with derived numbers (karyotype evolution).

Tetraploidy is by far the most frequent polyploid condition in both Apocynaceae s. str. and Asclepiadoideae. In general, the tetraploid condition is considered to be the most successful in higher plants (DeWet, 1980). Even Cactaceae do not depart from this, since infraspecific polyploidy, mainly based on autopolyploidy, is rare in the entire family (cf. Pinkava et al., 1985).

Van der Laan and Arends (1985) observed that most chromosomes of Apocynaceae s. str. (Apocynoideae and Rauvolfioideae) species fall in the range of 1 to 2 μm in length. Considerably longer chromosomes are found only in the tribes Alstonieae and Plumerieae (*Vallesia* and *Allamanda*, up to 3 μm long) and Tabernaemontaneae (*Tabernaemontana* and *Voacanga*, up to 3.5. μm long) of the Rauvolfioideae (data extracted from van der Laan & Arends, 1985; tribal disposition sensu Endress & Bruyns, 2000), and could indicate a similar trend in Asclepiadoideae, with larger chromosomes being predominantly confined to basal taxonomic units. On the average, however, there is no noticeable difference in chromosome length between the two subfamilies of Apocynaceae s. str. In both, average chromosome length is around 1.5 μm. The chromosomes of the generally woody Apocynaceae s. str. can be considered as small and are in the same range as those of the Periplocoideae, Secamonoideae, and some tribes of the Asclepiadoideae. Pattnaik et al. (1997), Raynaud (1991), and Nakamura (1991) published measurements of similar sizes for some stapeliads. However, the analysis of Pattnaik et al. (1997: Table 1, p. 89) revealed larger rather than smaller chromosomes in tetraploids as compared with diploids. For example, Pattnaik gave the karyotype length for *Orbea paradoxa* as 61.54 μm, whereas we measured 42.91 μm (Albers & Meve, unpublished). This surprising difference, which is even higher when comparing tetraploids with diploids of *Orbea variegata*, remains unexplained.

Comparing chromosome size in the Periplocoideae, Secamonoideae, and Asclepiadoideae, on av-

erage the size of the karyotype diminishes stepwise starting with rather large chromosomes in the basal Periplocoideae and ending with the smallest karyotype length in the presumedly most advanced tribe of the Asclepidoideae, the Asclepiadeae. In the asclepiads reduction of the genome size ($x = 10$, $x = 9$) is restricted to the tribe Asclepiadeae, which is also the only group characterized by having pendent pollinia. All other taxa (Secamoneideae, Fockeeae, Marsdenieae, and Ceropegieae) have the conserved $x = 11$, and are characterized by having erect pollinia. The erect position of pollinia has been shown to represent the primitive state in Asclepiadoideae by Kunze's (1993) careful morphological analysis. Within the tribe Asclepiadeae, subtribe Gonolobineae can be regarded as the karyologically most primitive, since its chromosomes are on the average slightly more than 1 μm long—the largest in Asclepiadeae, and approaching the length of those in the Ceropegieae. Gonolobinae also do not have numbers deviating from $x = 11$. This is an interesting result for the systematics of the subfamily Asclepiadoideae, since erect as well as more or less pendent, but mostly horizontally arranged pollinia have been reported for the Gonolobinae (cf. Kunze, 1995). Thus, both pollinarium morphology as well as karyological data provide evidence for a basal position of the Gonolobinae within the Asclepiadeae, and the results of the large cp DNA study by Potgieter and Albert (2001 this volume) do not refute this. Because they are restricted to the most advanced groups of the Asclepiadoideae, the subtribes Astephaninae, Metastelminae, and Oxypetalinae of Asclepiadeae, we regard reductions in the basic chromosome number as a relatively recent step in genome evolution within Asclepiadeae, which has taken place in parallel in the Old World (Astephaninae) and the New World (Metastelminae and Oxypetalinae).

Variation in the karyotype length is not restricted to the tribal level; it is also widespread at the generic level. In large genera, e.g., *Ceropegia* and *Brachystelma*, karyotype lengths can vary considerably from species to species, without compromising the generic affiliation of species with deviating chromosome size, such as *Brachystelma* (*Macropetalum*) *burchellii* (cf. Meve & Liede, 2001a). In small genera or groups of species considerable differences in chromosome size between the species might, however, question congeneric treatments. For example, the inclusion of *Larryleachia* (1.40 μm/chromosome length on average) in *Lavrania* (0.91 μm), as proposed by Bruyns (1999), is rejected by Meve and Liede (2001b). And in *Caralluma* s.l. karyotype length analysis will support new taxonomic solutions for this heterogeneous assemblage of species. In particular, *C. edulis* (ca. 1.5 μm) and *C. sinaica* (ca. 1.3 μm, Albers & Meve, unpublished data), which came out as a separate group in molecular studies (Meve & Liede, unpublished data), are additionally characterized by their large chromosomes. As to the direction in chromosome size evolution (from large to small) in the Asclepiadoideae as postulated above, the results we have for *Neoschumannia* support our ideas. *Neoschumannia*, which has the largest chromosomes in subfamily Asclepiadoideae (1.72 μm in *N. kamerunensis*) but a complex corona that is 3-seriate, has been regarded as a primitive member of the Ceropegieae (Meve, 1995b, 1997b).

In Marsdenieae we again have support for the hypothesis that basal taxa tend to have large chromosomes, since Omlor (1998) regarded the genera *Marsdenia* and *Telosma* (those with large chromosomes) as basal in the tribe. In contrast, the highly diverse and specialized Asian/Australian genus *Hoya*, where many of the up to 300 species (Forster et al., 1998) show derived features as such as herbaceous epiphytic growth, succulent leaves, clear latex, and a germination crest along the inner edge of the pollinium, possesses rather small chromosomes (0.91 μm on average for the genus, Fig. 1; for sizes of *Hoya* chromosomes see also Nakamura, 1992, 1993).

Considering the distribution patterns of basic chromosome numbers and of the different karyotype sizes in Asclepiadoideae, our data suggest Africa as the common area where (karyotype) evolution began. This conclusion coincides with that of van der Laan and Arends (1985) for Apocynoideae and Rauvolfioideae, where most of the genera with derived basic chromosome numbers occur outside the African continent (cf. *Catharanthus* and *Apocynum* ($x = 8$) in Madagascar, the Middle East, and North America; *Plumeria* and *Allamanda* ($x = 9$) in the Americas; *Odontadenia* and *Beaumontia* ($x = 12$) in America and Asia). Of the ca. 40 genera of Apocynaceae s. str. occurring in Africa, 35 have been karyologically investigated. Of these, only 3 are not characterized by $x = 11$, again supporting the idea of an African origin of the Apocynaceae s.l.

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Appendix 1. New chromosome numbers in Periplocoideae, Secamonoideae, and Asclepiadoideae (Apocynaceae). The table is differentiated in the two categories: (1) New and first chromosome counts for taxon (unmarked); and (2) New counts confirming previous chromosome numbers (marked by #); additionally, taxa marked by an asterix (*) served as vouchers for chromosome size analysis, but their chromosome numbers were published previously.

Taxon	2*n*	Locality	Voucher
PERIPLOCOIDEAE			
***Camptocarpus* Decne.**			
C. crassifolius Decne.	22	MADAGASCAR: s. loc.	*Petignat s.n.* [ULM]
***Cryptolepis* R. Br.**			
C. decidua (Planch. ex Hook. f. & Benth.) N. E. Br.	22	NAMIBIA: Warmbad	*Verhoeven 203*
C. oblongifolia (Meisn.) Schltr.	22	R.S.A.: Eastern Cape Prov., Vredefort	*du Preez s.n.*
C. sanguinolenta (Lindl.) Schltr.	22	NIGERIA: s. loc.	*ex hort.* BG MSUN [MSUN]
***Cryptostegia* R. Br.**			
C. madagascariensis Bojer ex Decne.	22	s. loc.	*ex hort* MSUN
***Ectadium* E. Mey.**			
E. virgatum E. Mey. var. *virgatum*	22	NAMIBIA: 16 km O Lüderitz	*Albers 2413* [MSUN]
***Mondia* Skeels**			
M. whitei (Hook. f.) Skeels	22	TANZANIA: S slope Mt. Kilimanjaro, Msaranga Valley	*Liede & Meve 3351* [UBT]
***Periploca* L.**			
P. aphylla Decne.	22	ISRAEL: Daragoth (Dead Sea Area), near road to Ma'aleh	*Avishai s.n.*
P. visciformis K. Schum.	44	YEMEN: Jabal Haraz, ca. 25 km S Manákhah	*Mangelsdorff Y15* [in hort UBT]
***Petopentia* Bullock**			
P. natalensis (Schltr.) Bullock	22	*ex hort.* Kiel	*ex hort. Kiel*
***Raphionacme* Harv.**			
R. brownii Scott-Elliott	22	IVORY COAST (STATE): Korhogo, Granitinselberg (IB2)	*Porembski & Biedinger 1488* [MSUN]
R. flanaganii Schltr.	22	R.S.A.: Kwazulu-Natal, Pietermaritzburg, S Ashburn Stn.	*Albers & Balkwill in K 1577* [MSUN]
R. globosa K. Schum.	22	TANZANIA: Ruvuma Prov.	*Specks 286* [MSUN]
R. hirsuta (E. Mey.) R. A. Dyer	44	R.S.A.: Northern Prov., Sterkfontein caves	*Venter 9110*
R. lanceolata Schinz	22	IVORY COAST (STATE): s. loc.	*Porembski 271* [MSUN]
R. madiensis S. Moore	22	TANZANIA: Ruvuma Prov., Namchwea Hill	*E. & M. Specks 494* [MSUN]
R. palustris Venter & R. L. Verh.	44	R.S.A: s. loc.	*Stork 24* ex hort MSUN
R. splendens Schltr.	22	TANZANIA: s. loc.	*Specks 692* [MSUN]
***Schlechterella* K. Schum.**			
S. abyssinica (Chiov.) Venter & R. L. Verh.	22	KENYA: Forole	*Newton 4555* [EA]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Stomatostemma* N. E. Br.**			
S. monteiroae N. E. Br.	22	s. loc.	*s.n. sub IPPS 1427* [MSUN]
***Tacazzea* Decne.**			
T. apiculata Oliv.	22	R.S.A.: Northern Prov.	*Venter 9188* [K]
SECAMONOIDEAE			
***Secamone* R. Br.**			
S. alpinii Schult.	22	R.S.A.: Western Cape Prov., Leipoldt's Grave	*Liede 2548*
S. filiformis (L. f.) J. H. Ross	22	R.S.A.: Northern Prov., Venda	*Liede 632* [K, MSUN]
S. parviflora (Oliv.) Bullock	22	KENYA: Kwale, Shimoni	*Liede & Newton 3196* [E, MSUN, ULM]
S. parviflora (Oliv.) Bullock	44	KENYA: Kilifi, GEDE National Monument	*Liede & Newton 3198*
S. punctulata Decne.	22	TANZANIA: Moshi, Lake Chala	*A. & C. Hemp s.n.* [UBT]
ASCLEPIADOIDEAE			
Tribe: FOCKEEAE			
***Cibirhiza* Bruyns**			
* *C. albersiana* Kunze, Meve & Liede	22	TANZANIA: Dodoma Prov., 5 km S Mpwapwa	*Specks 248*
C. dhofarensis Bruyns	22	OMAN: Dhofar, 25 km W Salalah	*Butler s.n.* [UBT]
***Fockea* Endl.**			
F. angustifolia K. Schum.	22	ZIMBABWE: Hwange, Deka Matetsi	*Albers & Meve 524*
F. capensis Endl.	22	R.S.A.: Western Cape Prov., s. loc.	*ex hort, Kiel* [MSUN]
F. edulis (Thunb.) K. Schum.	22	R.S.A.: s. loc.	*s. coll.* [MSUN]
F. sinuata (E. Mey.) E. A. Bruce	22	R.S.A.: Eastern Cape Prov., Willowmore	*Bruyns 5075*
Tribe: MARSDENIEAE			
***Cionura* Griseb.**			
C. erecta (L.) Griseb.	22	TURKEY: Side, Manaugat	*Heyne 120* [UBT]
***Dischidia* R. Br.**			
D. bengalensis Colebr.	22	s. loc.	*Cumming s.n.* [MSUN]
D. hirsuta L.	22	PHILIPPINES: Quezon Natl. Park	*S. Schneidt s.n.* [ULM]
D. (Dischidiopsis) luzonica Schltr.	22	PHILIPPINES: Mt. Makiling	*Liede 3262*
D. nummularia Blume	22	PHILIPPINES: Quezon Natl. Park, from Pagbilao to Atimonan	*Schneidt & Liede 96-18* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Dregea* E. Mey.**			
D. rubicunda K. Schum.	22	KENYA: GEDE National Monument, Kilifi	*Liede & Newton 3199* [ULM]
D. schimperi (Decne.) Bullock	22	ZIMBABWE: Thomson Junction between Victoria Falls and Hwange	*Albers, Liede & Meve 520*
***Gymnema* R. Br.**			
# *G. sylvestre* R. Br.	22	CAMEROON: 20 km E Mokolo	*Meve 919* [B, UBT]
***Hoya* R. Br.**			
H. australis R. Br. ex Traill	22	s. loc.	*van Donkelaar s.n.* [in hort UBT]
H. camphorifolia Warburg	22	PHILIPPINES: Quezon, Quezon National Park	*Schneidt 96-20* [UBT]
H. heuschkeliana Kloppenburg	22	PHILIPPINES: Luzon, Lake Bulusan	*Schneidt 96-96* [UBT, ULM]
# *H. longifolia* Wall.	22	*ex hort.* BG Münster	*Helmcker s.n.* [in hort MSUN]
H. meliflua Merr.	22	PHILIPPINES: Luzon, Mt. Makiling	*Liede 3274* [MSUN, ULM]
***Marsdenia* R. Br.**			
M. linearis Decne.	22	CUBA: s. loc.	*s. coll.*
M. megalantha Goyder & Morillo	22	BRAZIL: Bahia, Mun, Iramaia, 42 km W Martacas towards Iramaia	*Taylor et al. 1557* [K, MO, MSUN]
M. rostrata R. Br.	22	AUSTRALIA: NSW, 2 km S Kioloa	Meve & Hellbrügge 791 [MSUN]
***Telosma* Coville**			
T. cordata Merr.	22	PHILIPPINES: Luzon, Alaminos, Hundred Islands Natl. Park	*Schneidt & Liede 96-105* [AUH]
T. accedens Blume	22	PHILIPPINES: Laguna Prov. Mt Makiling	*Schneidt 96-45* [UBT]
Tribe: CEROPEGIEAE			
***Angolluma* Munster (= *Pachycymbium* Leach *p.p.*, = *Stultitia* Phillips)**			
# *A. abayensis* (M. G. Gilbert) Plowes cf.	22	ETHIOPIA: Lake Abaye	*Frank 64* [MSUN]
A. commutata (A. Berger) Plowes	22	SAUDI ARABIA: s. loc.	*Collenette 8255*
# *A. decaisneana* (Lem.) L. E. Newton	22	ALGERIA: Tasille (Sahara)	*Plowes 3971*
A. denboefii (Lavranos) Plowes	22	TANZANIA: Himo	*Masinde 889* [UBT]
A. eremastrum Schwartz	22	YEMEN: 20 km E Al Dann	*Mangelsdorff Y25* [ULM]
A. hesperidum (Maire) Plowes	22	MOROCCO: 36 km from Taquist, 1 km above Torres-de-Alcalá	*t'Hart 67-106B* [MSUN]
A. laikipiensis (M. G. Gilbert) Plowes	22	KENYA: 43 km NE Rumuruti	*Newton 4221* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
# *A. laticorona* (M. G. Gilbert) Plowes	22	ETHIOPIA: 2 km S Modjo, SHEWA	*Gilbert s.n. sub Plowes 7695* [MSUN]
# *A. lugardii* (N. E. Br.) Plowes	22	R.S.A.: Northern Cape Prov., 20 km N Bladgrond	*Meve & Liede 613* [MSUN]
A. sacculata (N. E. Br.) Plowes	22	SAUDI ARABIA: s. loc.	*s. coll., s.n.*
# *A. schweinfurthii* (Berger) Plowes	22	TANZANIA: s. loc.	*Speckes 805*
A. semitubiflora L. E. Newton	22	TANZANIA: Kisite Crater	*Newton 3419* [K, EA, MSUN]
# *A. subterranea* (E. A. Bruce & P. R. O. Bally) Plowes	22	KENYA: Mt. Maktau	*Meve et al. 946* [MSUN]
# *A. tubiformis* (E. A. Bruce & P. R. O. Bally) Plowes	22	KENYA: 5 km N Longobito	*Meve, Newton & Goyder 958*
A. vibratilis (E. A. Bruce & P. R. O. Bally) M. G. Gilbert	44	KENYA: 36 km N Horr	*Cumming 1443* [MSUN]
# *A. wissmannii* (O. Schwartz) Plowes	22	OMAN: Sarfait road, 4 km E of turn to Rakhyut	*Jonkers 66* [MSUN]
***Brachystelma* Sims**			
B. barberae Harvey ex Hook. f.	22	ZIMBABWE: W Bulawayo	*Albers 2570* [MSUN]
* *B. bracteolatum* Meve	22	NIGERIA: Jos Plateau	*Specks 549* [K, MSUN]
B. buchananii N. E. Br.	22	TANZANIA: Ruvuma	*Specks 378* [MSUN]
B. burchellii (Decne.) Peckover	22	R.S.A.: Free State, Bloemfontein	*sub Specks 3156* [MSUN, UBT]
B. christianae Peckover	22	R.S.A.: KwaZulu-Natal	*sub Specks 2531* [MSUN]
B. decipiens N. E. Br.	22	R.S.A.: Eastern Cape, Transkei	*sub Specks 2390* [MSUN]
B. filifolium Schltr.	22	s. loc.	*ex hort.* [MSUN]
# *B. gracile* E. A. Bruce	22	ZIMBABWE: Bulawayo, Hyde Park	*Albers 2558*
B. kituloensis Goyder	22	TANZANIA: Makinda, Livingstone Mts.	*Specks 599* [MSUN]
B. lancasteri C. Boele	22	ZIMBABWE: Bulawayo outskirts	*Albers 2573* [MSUN]
B. lineare A. Rich.	22	ETHIOPIA: 27 km SW Bah Dar	*Specks 432* [MSUN]
B. macropetalum N. E. Br.	22	R.S.A.: s. loc.	*sub Specks 2986* [MSUN]
B. megasepalum Peckover	22	TANZANIA: Ruvuma Prov., Kitobaloma	*Specks 748* [MSUN]
B. meyerianum Schltr.	22	R.S.A.: Eastern Cape Prov., Transkei	*sub Specks 2987* [MSUN]
# *B. mortonii* C. C. Walker	22	IVORY COAST (STATE): Comoé-Nationalpark, 6.5 km N Lola Plain	*Porembski sub MS 651* [K, MSUN]
B. nanum N. E. Br.	22	R.S.A.: Mpumalanga	*Peckover sub Specks 2988* [MSUN]
B. remotum R. A. Dyer	22	R.S.A.: Kwazulu-Natal, 45 km SE Wakkerstroom	*Craib s.n.*
B. richardsii Peckover	22	TANZANIA: Ruvuma Prov., Mhukuru	*Specks 762* [MSUN]
B. rubellum (E. Mey.) Peckover	22	R.S.A. Kwazulu-Natal, Thornville, Tala Hill	*Cumming 3565*
B. simplex Schltr.	22	IVORY COAST (STATE): Comoé-Nationalpark, 6.5 km N Lola Plain	*Porembski 8648* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Caralluma* R. Br. s.l.**			
# *C. acutangula* (Decne.) N. E. Br.	22	KENYA: Archer's Post	*Meve 964*
# *C. adenensis* (Deflers) A. Berger	22	OMAN: Wadi Afal	*Jonkers 85* [MSUN]
# *C. adscendens* (Roxb.) R. Br.	22	INDIA: Bangalore, Tahlly	*Bruyns 5937*
# *C. adscendens* var. *attenuata* Wight	22	INDIA: 72 km of Tirumyam direction of Madurai	*Sarkaria J18-90* [MSUN]
# *C. adscendens* var. *fimbriata* (Wall.) Gravely & Mayur.	22	INDIA: Pasarny Ghat Distr., Wai-Mahableshwar Rd., 3–4 km beyond Wai	*Sarkaria 166-77*
C. adscendens var. *geniculata* Gravely & Mayur.	22	INDIA: Marathumalai Hill near Nagercoil	*Sarkaria J30-90* [MSUN]
C. adscendens var. *gracilis* Gravely & Mayur.	22	INDIA: 9 km beyond Tirumykm, near Malai Kuddi Patti	*Sarkaria 62-78*
C. adscendens var. *gracilis* Gravely & Mayur	22/44	INDIA: Yercaud Hill	*Sarkaria J 32-90* [MSUN]
C. arabica N. E. Br.	22	OMAN: Ra's al-Hamra	*Jonkers 16* [ON]
# *C. arachnoidea* (P. R. O. Bally) M. G. Gilbert var. *arachnoidea*	22	KENYA: between Kabernat and Kapengunia	*Hartmann & Newton 28406* [MSUN]
C. baradii Lavranos	22	SOMALIA: 34 km W Hobiyo	*Lavranos et al. 23338* [UPS]
C. bhupinderana Sarkaria	22	INDIA: Palamkottai–Tuticorn Rd., base of Vallandu Hill	*Sarkaria 28-90* [MSUN]
* *C. burchardii* N. E. Br. subsp. *burchardii*	130–132	SPAIN: Canary Islands, Fuerteventura, Betancuria, Bco. de Ajuy	*Wiemers s.n.* [MSUN]
* *C. burchardii* subsp. *maura* (Maire) Meve & F. Albers	66	MOROCCO: 28 km N Sidni Ifni	*Jonkers 223*
# *C. cicatricosa* (Deflers) N. E. Br.	22	YEMEN: Hammam Ali	*Noltee 807* [MSUN]
# *C. crenulata* Wall.	22	INDIA: Bangalore-Kodai road, 2 km beyond Narsapur	*Sarkaria 10-77* [MSUN]
# *C. dalzielii* N. E. Br.	22	CAMEROON: W Mindif, between Maroua and Mindif	*Specks s.n.*
# *C. dicapuae* Chiov. subsp. *dicapuae*	22	KENYA: Longobito	*Meve 955*
# *C. diffusa* (Wight) N. E. Br.	22	INDIA: Tamkur, near Sideshurai Ganga Temple Hill	*Sarkaria 81-75*
# *C. edithae* N. E. Br.	22	ETHIOPIA: S Dire Dawa	*Frank 57* [MSUN]
# *C. edulis* (Edgew.) Benth. & Hook.	22	ex hort. Basel	*s. coll.* [MSUN]
C. edwardsiae (M. G. Gilbert) M. G. Gilbert	22	KENYA: near Turbi	*Hartmann 21393* [MSUN]
# *C. europaea* (Guss.) N. E. Br. var. *europaea*	22	MOROCCO: 55 km from Nador on road to Guercif	*t'Hart 67-33B* [MSUN]
* *C. europaea* (Guss.) N. E. Br. var. *europaea*	22	SPAIN: Almeira, Capo de Gata	*Albers 87-23-004-20* [MSUN]
# *C. europaea* var. *judaica* M. Zohary	22	ISRAEL: Har Hanegev (Jebel Hursha)	*Chaouat s.n.* [HUJ, MSUN]
C. flava N. E. Br.	22	OMAN: Dhofar, Jabal Qamar, on road to Sarfait	*Jonkers 150* [MSUN]
# *C. foetida* E. A. Bruce	22	KENYA: NE Rumuruti, Kisima Ranch	*Meve 950* [UBT]
C. furta P. R. O. Bally	22	DJIBOUTI: s. loc.	*Butler D106* [MSUN]
C. gracilipes K. Schum.	22	TANZANIA: Pare	*Specks 632* [MSUN]
# *C. indica* (Wight & Arn.) N. E. Br.	22	INDIA: 13 km beyond Tiruchirapalli in direction to Puddukottai	*Sarkaria J 11-90*

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
# *C. joannis* Maire	66	MOROCCO: Aoulez, 35 km on the road Taliouine to Agadir	*de Wilde s.n.*
C. lavrani Rauh & Wertel	22	YEMEN: s. loc.	*Frank 119* [MSUN, UBT]
C. moniliformis P. R. O. Bally	22	SOMALIA: 4.5 km N Galgallo	*Koenen & Krapp 22678* [MSUN]
# *C. munbyana* (Decne. ex Munby) N. E. Br.	22	SPAIN: Murcia	*Berthet s.n.* [UBT]
C. pauciflora (Wight) N. E. Br	22	INDIA: Palamkottai	*Bruyns s.n.*
# *C. peckii* P. R. O. Bally	22	s. loc.	*Plowes 7948* [MSUN]
C. priogonium K. Schum.	22	SOMALIA: 26 km N Mogadiscio, ca. 3 km NE Malad	*Koenen & Krapp 49388* [MSUN]
# *C. procumbens* Gravely & Mayur.	22	INDIA: Masuthuamalai Hill, South Travancore	*Sarkaria 108-77*
# *C. sarkariae* Lavranos & Frandsen	22	INDIA: 8 km W Madurai, Madurai-Usilampatti Road, base of Nagamalai hill	*Sarkaria 23-90*
* *C. sinaica* (Decne.) A. Berger	22	ISRAEL: Dead Sea, Dragot shore	*Bruyns 2484* [MSUN]
C. socotrana (Balf. f.) N.E. Br.	22	SOMALIA: 3 km E Los Anod	*Lavranos s.n.*
# *C. speciosa* N. E. Br.	22	KENYA: Archer's Post	*Meve 965*
C. staintonii Hara	22	NEPAL: Jiamiri (Bheri River Valley)	*Bruyns 2515* [MSUN, K]
# *C. stalagmifera* C. E. C. Fischer	22	INDIA: Tirumyam-Madurai, km 72.5	*Sarkaria J17A-90* [MSUN]
# *C. subulata* (Forssk.) Decne.	44	YEMEN: 6 km N Bajil	*Barad 11705*
# *C. tuberculata* N. E. Br.	22	INDIA: 2 km NW Jammu (near Magkola-Kujagh)	*Sarkaria 43-75*
* *C. turneri* E. A. Bruce	22	KENYA: Lake Victoria	*Hartman & Newton 28587* [MSUN]
# *C. umbellata* Haw.	22	INDIA: Tiruchirapalli–Puddukotai road	*Sarkaria 55-77*
***Ceropegia* L.**			
C. africana R. Br. subsp. *africana*	22	R.S.A.: Kzwazulu-Natal Prov., Oribi-Gorge	*Balkwill K 1570*
C. albisepta Jum & H. Perrier	22	MADAGASCAR: betw. Antsirabe and Ambositra (W side of Col des Tapias)	*Lavranos et al. 29964* [MSUN]
C. arabica H. Huber	22	YEMEN: Ussab al Áli	*Mangelsdorff Y26* [UBT]
C. aristolochioides Decne. subsp. *aristolochioides*	22	KENYA: Rift Valley Province, Kajiado District, Alhi River	*Masinde 684* [MSUN]
# *C. aristolochioides* Decne. subsp. *deflersiana* Bruyns	22	YEMEN: Wadi Rima, ca. 35 km W Madinat ash Shirq	*Mangelsdorff Y11* [MSUN]
C. bulbosa Roxb. ("*C. vignaldiana*")	22	ETHIOPIA: Harar, Mt. Achim	*Specks 429* [MSUN]
C. cimiciodora Obermeyer	22	R.S.A.: s. loc.	*ex BG Bonn 2535* [MSUN]
C. crassifolia var. *copleyae* (Bruce & Bally) H. Huber	22	KENYA: Nairobi, near Airport	*Masinde & Meve M 874* [EA, MSUN]
C. cumingiana Decne.	22	PHILIPPINES: Luzon, Mt. Makiling	*Liede 3250* [MSUN]
* *C. dichotoma* Haw. subsp. *dichotoma*	22	SPAIN: Canary Islands, Tenerife, Punta de Teno	*Meve s.n.* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
C. dimorpha Humbert	22	MADAGASCAR: between Ihosy and Ranohira, 10.5 km to Ranohira	*Liede 2638* [MSUN]
C. distincta N. E. Br. ("*C. brevirostre*")	22	TANZANIA: Amani	*Liede & Meve 3379* [EA, UBT]
# *C. elegans* Wall.	22	INDIA: Konanad	*Bruyns 5906* [MSUN]
C. filiformis (Burch.) Schltr.	22	R.S.A.: Northern Cape Prov., Loxton	*Bruyns 6683*
C. gilgiana Werderm.	22	TANZANIA: SW Itigi	*M. & E. Specks 1 039* [MSUN, UBT]
C. hermannii Rauh & M. Teissier	22	MADAGASCAR: Tuléar, E de la Table	*Petignat 455*
C. humbertii H. Huber	22	MADAGASCAR: Montagne de Francais	*Mangelsdorff M 22* [MSUN]
C. intermedia Wight	22	INDIA: Ebanad	*Bruyns 5903*
# *C. juncea* Roxb.	44	INDIA: Tasparc, Vizakapatnam	*Bruyns s.n.*
C. lugardiae N. E. Br.	22	NAMIBIA: Steinhausen, Farm Wunderland	*Grabow s.n. sub As 103*
C. meleagris H. Huber	22	INDIA: s. loc.	*s.n. ex Shirley* [MSUN]
C. meyeri-johannis Engl.	22	KENYA: Mt. Kasigau, SW side	*Meve et al. 936* [K, MSUN]
C. multiflora Bak. subsp. *multiflora*	22	ZIMBABWE: Bulawayo, Hyde Park	*Albers 2559*
# *C. nilotica* Kotschy	22	MALAWI: Njakwa Gorge, S Rukuru River at road from E Kwendeni to Rumpi	*Thiede 2151* [MSUN]
C. occidentalis R. A. Dyer	22	R.S.A.: Western Cape Prov., Strandfontein	*v. Jaarsveld & Bruyns 2321* [MSUN]
C. petignatii Rauh	22	MADAGASCAR: 30 km N Tuléar, near Mora-Mora	*ex Petignat 296* [MSUN]
C. powysii D. V. Field	22	KENYA: Mt. Maktau	*Meve 941* [K, MSUN]
C. racemosa N. E. Br. susbp. *glabra* H. Huber	44	MADAGASCAR: Ankarana	*Mangelsdorff M 27* [MSUN]
C. racemosa N. E. Br. subsp. *racemosa*	22	TANZANIA: Kilimanjaro, Lake Chala	*Meve & Liede 3355* [EA, UBT]
# *C. rupicola* Deflers	22	YEMEN: Djebel Haraz	*Mangelsdorff Y 13* [MSUN]
C. sankuruensis Schltr.	22	CAMEROON: Mt Cameroon, W Likombe	*Meve 909* [K, MSUN]
C. saxatilis Jum. & H. Perrier	22	MADAGASCAR: Ankarana Mts., Montagne de Francais	*Mangelsdorff s.n.* [MSUN]
C. simoneae Rauh	22	MADAGASCAR: forest between Tishombé and Ihado	*Rauh 73117* [HEID, MSUN]
C. stapeliaeformis Haw.	22	s. loc.	*s.n. ex Palmengarten*
C. stentiae E. A. Bruce	22	R.S.A.: North-West Prov., NW Potchefstroom	*Albers et al. 3529* [MSUN]
* *C. striata* Meve & Masinde	22	MADAGASCAR: Antsirabe	*Rauh 75007* [HEID, MSUN]
C. subaphylla K. Schum.	22	SAUDI ARABIA: Muhayl	*Collenette 7307* [MSUN]
# *C. thwaitesii* Hook.	22	INDIA: Davikolam	*Bruyns 5944*
# *C. variegata* Decne.	22	KENYA: 3 km N Maralal	*Masinde & Meve 871* [MSUN]
***Duvalia* Haw.**			
* *D. angustiloba* N. E. Br.	22	R.S.A: Western Cape Prov., 82 km E Beaufort West	*Meve 319* [MSUN, NBG]
* *D. caespitosa* (Mass.) Haw. var. *caespitosa*	44	R.S.A: Western Cape Prov., betw. Muiskraal and Barrydale, nr Kleindoornrivier	*Albers & Meve 129* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
* *D. caespitosa* (Mass.) Haw. var. *compacta* (Haw.) Meve	44	R.S.A: Western Cape Prov., E VanRhynsdorp	*Meve 263* [MSUN]
* *D. elegans* (Mass.) Haw.	22	R.S.A: Western Cape Prov., 7.5 km N McGregor	*Meve 383* [MSUN]
* *D. immaculata* (Lückh.) Bayer ex L. C. Leach	66	R.S.A: Western Cape Prov., Gouritzmond	*Meve 401* [MSUN]
# *D. maculata* N. E. Br.	22	R.S.A: Western Cape Prov., Sterkfontein	*Bruyns 6289*
# *D. sulcata* N. E. Br. subsp. *sulcata*	44	YEMEN: Lodar	*Hanacek 286* [in hort. UBT]
D. sulcata N. E. Br. subsp. *somalensis* (Lavranos) Meve	22	DJIBOUTI: s. loc.	*Butler D105*
***Duvaliandra* M. G. Gilbert**			
# *D. dioscorides* (Lavranos) M. G. Gilbert	22	YEMEN: Socotra, Hadiboh	*Orlando s.n.* [UBT]
***Echidnopsis* Hook. f.**			
E. angustiloba E. A. Bruce & P. R. O. Bally	22	KENYA: ca. 5 km N Longobito	*Meve 959* [K, MSUN, UBT]
E. archeri P. R. O. Bally	22	KENYA: Nguruman Escarpment, Oloibitato River near Hayton's Falls	*Archer in Bally S325* [K, ZSS]
E. ballyi (M. Lapostolle) P. R. O. Bally	22	SOMALIA: s. loc.	*Plowes 6609*
E. bihendulensis P. R. O. Bally	22	SOMALIA: below the Sheik Pass at Bihendula	*Reynolds 1956*
E. cereiformis Hook. f.	22	SUDAN: Erkovit, Jebel Aulini	*Hartmann 21505* [MSUN]
# *E. dammaniana* Sprenger	22	KENYA: S Gatap	*Hartmann & Newton 28557* [MSUN]
E. globosa Thulin & Hjertson	22	YEMEN: Hadramaut, 14 km from the turning to the Masila field	*Thulin et al. 8248* [K, UPS]
# *E. leachii* Lavranos	22	TANZANIA: Dodoma	*Specks 1264* [UBT]
# *E. malum* (Lavranos) Bruyns	22	SOMALIA: 40 km NE Mogadishu	*Lavranos 23224A*
# *E. mijerteina* Lavranos	22	SOMALIA: 2 km S Eil	*Lavranos 8446*
# *E. repens* R. A. Dyer & Verd.	22	KENYA: Mt. Maktau	*Meve 942*
E. scutellata subsp. *australis* Bruyns	22	KENYA: Marsabit, N side of Gof Chjoba crater	*Lavranos & Bleck 19527*
E. scutellata subsp. *dhofarensis* Bruyns	22	OMAN: Dhofar Province, on road from Thamarit to Salalah, Agabat al Hatab	*Miller 2811* [E]
# *E. scutellata* subsp. *planiflora* (P. R. O. Bally) Bruyns	22	ETHIOPIA: Jijiga, Marda Pass	*Gilbert s.n.* sub *Plowes 4264*
E. scutellata subsp. *planiflora* (P. R. O. Bally) Bruyns	44	SOMALIA: 4 km NW Erigavo	*Lavranos 7325* [FT]
# *E. scutellata* (Deflers) A. Berger subsp. *scutellata*	22	YEMEN: road from Kuhlan to Hajjah	*Miller & Long 3259* [E]
E. sharpei subsp. *ciliata* (P. R. O. Bally) Bruyns	22	SOMALIA: Sheik Pass	*Bailes 134* [MSUN]
E. sharpei A. C. White & B. Sloane subsp. *sharpei*	22	KENYA: S Moyale	*Hartmann & Newton 21381* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
# *E. squamulata* (Decne.) P. R. O. Bally	44	YEMEN: Amiri Highlands, 6 km NE Dhala	*Lavranos 1869* [K, PRE]
E. urceolata P. R. O. Bally	22	KENYA: s. loc.	*Lavranos 12220*
E. urceolata P. R. O. Bally	44	YEMEN: 15 km S Taizz (Aden road)	*Lavranos & Newton 13101*
E. virchowii K. Schum.	22	SOMALIA: s. loc.	*Bailes sub Plowes 6610* [MSUN]
# *E. watsonii* P. R. O. Bally	44	SOMALIA: 8 km W Bawn	*Lavranos 10421* [MSUN]
E. yemenensis Plowes	22	YEMEN: base of Menakha Pass near Suq al Khamis	*Plowes & Barad 7764* [SRGH]
***Edithcolea* N. E. Br.**			
E. grandis N. E. Br.	22	KENYA: Ndi Area	*Meve 932*
***Heterostemma* Wight & Arn.**			
H. acuminatum Decne.	22	AUSTRALIA: Port Curtis Distr., Olsens Caves	*Forster 5090* [BRI, K, L, MEL, MO]
H. herbertii Elmer	22	PHILIPPINES: Luzon, Mt Makiling	*Liede 3271b* [UBT]
***Hoodia* Sweet ex Decne.**			
# *H. gordonii* (Masson) Sweet	22	NAMIBIA: ca. 30 km S Warmbad, Farm Eendoorn (Pretorius)	*Meve & Struck 192* [MSUN]
H. juttae Dinter	22	NAMIBIA: Vredenhof	*Bruyns 3508* [MSUN]
H. longispina Plowes	22	NAMIBIA: Witpütz	*Albers & Meve 85* [MSUN]
H. officinalis (N. E. Br.) Plowes subsp. *delaetiana* (Dinter) Bruyns	22	NAMIBIA: Klinghardt	*Hammer 914*
H. pedicellata (Schinz) Plowes	22	NAMIBIA: Rössingberge	*Albers 2718* [MSUN]
H. pillansii N. E. Br.	22	R.S.A.: s. loc.	*s. coll. sub Al 2510*
H. pilifera (L. f.) Plowes subsp. *pilifera*	22	R.S.A.: Western Cape Prov., ca. 19 km SE Oudtshoorn	*Meve 406* [MSUN]
# *H. ruschii* Dinter	22	NAMIBIA: Uri Hauchab	*Jürgens 91245*
***Huernia* R. Br.**			
H. arabica N. E. Br.	22	YEMEN: 3 km N Ar Rahida	*Barad 11752* [MSUN]
H. archeri L. C. Leach	44	KENYA: 100 km W Malindi, Galana River, Lali Hill	*Powys 804*
# *H. aspera* N. E. Br.	44	KENYA: Mt Maktau	*Meve 943b* [MSUN]
H. boleana M. G. Gilbert	22	ETHIOPIA: N Addis Ababa, Bole Valley	*Horwood 11072* [MSUN]
H. brevirostris N. E. Br. subsp. *brevirostris*	22	R.S.A.: Eastern Cape Prov., Steytlerville, Springbokvlakte	*Lavranos & Pehlemann 19868*
H. erinacea P. R. O. Bally	44	KENYA: between Moyale and Marsabit, Sololo hill	*Cumming 1416*
# *H. guttata* (Masson) Haw.	22	R.S.A.: Western Cape Prov., near Calitzdorp Dam	*Leach & Rossouw 16147* [MSUN, NBG]
# *H. hallii* E. Lamb & B. M. Lamb	22	NAMIBIA: ca. 29 km E Aus, Farm Plateau	*Meve & Struck 181* [MSUN]
# *H. humilis* (Masson) Haw.	22	R.S.A.: Eastern Cape Prov., Fraserburg, Tafelberg	*LCL 17710*
# *H. keniensis* R. E. Fries	44	KENYA: 30 km N Maralal	*Meve 963* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
# *H. keniensis* R. E. Fries var. *keniensis*	44	KENYA: Tugen Hills	*Newton 4283*
H. keniensis var. *nairobiensis* A. C. White & B. Sloane	22	KENYA: 4 km N Narock	*Cumming 1032* [MSUN]
H. lenewtonii Plowes	22	KENYA: E Lake Turkana, Sul-Sul Mudde	*Newton & Powys 3703* [EA, K]
# *H. nigeriana* Lavranos	22	NIGERIA: s. loc.	*Plowes 7856* [MSUN]
H. pendula E. A. Bruce	22	R.S.A.: Eastern Cape Prov., Transkei, s. loc.	*s. coll*
# *H. penzigii* N. E. Br.	22	YEMEN: Taizz, 15 km NE Airport	*Plowes 7803* [MSUN]
# *H. procumbens* (R. A. Dyer) L. C. Leach	44	R.S.A.: Mpumalanga, Masisi Village	*Hardy 5404* [NBG]
# *H. reticulata* (Masson) Haw.	22	R.S.A.: Western Cape Prov., VanRhynsdorp, Giftberg	*Lavranos 28207*
H. rosea Newton & Lavranos	22	YEMEN: 5 km W Al Magrabah	*Noltee 1528* [MSUN]
H. rubra Plowes	22	YEMEN: Ramadah	*Noltee 2092* [MSUN]
# *H. saudi-arabica* D. V. Field	22	YEMEN: Taifa/Hadda	*Lavranos & Collenette 18467* [MSUN]
H. thudichumii L. C. Leach	22	R.S.A.: Eastern Cape Prov., s. loc.	*Albers 2521* [MSUN]
# *H. verekeri* Stent var. *verekeri*	22	ZIMBABWE: NW Hwange, "Thomson Junction"	*Albers, Liede & Meve 523* [MSUN]
# *H. volkartii* Peitsch. ex Werderm. & Peitsch. var. *volkartii*	44	ZIMBABWE: Buchwa, Old Iron Mine (Masvingo Distr.)	*Erwee s.n. sub Albers 2574*
H. zebrina N. E. Br. subsp. *magniflora* (Phillips) L. C. Leach	22	R.S.A.: Northern Prov., Zaaiplaats bei Potgietersrust, Tin-Mine	*Balkwill K 1567*
# *H. zebrina* n. E. Br. subsp. *zebrina*	22	R.S.A.: 23°23′S, 29°45′E	
***Huerniopsis* R. Br.**			
* *H. decipiens* N. E. Br.	22	R.S.A.: Northern Cape Prov., 11.4 km E Kuruman	*Meve & Liede 580* [MSUN]
***Larryleachia* Plowes**			
# *L. cactiformis* (Hook.) Bruyns	22	NAMIBIA: s. loc.	*Albers 2513* [MSUN]
* *L. marlothii* (N. E. Br.) Bruyns	22	NAMIBIA: 8 km S Rosh Pinah	*Albers & Meve 45* [MSUN]
* *L. picta* (N. E. Br.) Bruyns subsp. *picta*	22	NAMIBIA: ca. 29 km E Aus, Farm Plateau	*Meve & Struck 178* [MSUN]
***Lavrania* Plowes**			
L. haagnerae Plowes	22	NAMIBIA: 40–50 km SE Sesfontein, Khowarib Gorge	*Haagner sub Plowes 5046* [PRE]
***Leptadenia* R. Br.**			
L. pyrotechnica Decne.	22	EGYPT: 24 km W Safaga	*Albers 3643* [MSUN]
L. hastata Decne.	22	GAMBIA: Abouko Natl. Park	*S. Huber s.n.*
***Neoschumannia* Schltr.**			
N. cardinea (S. Moore) Meve	22	TANZANIA: E Usambara, Amani Forest Reserve	*Meve & Liede 3359* [B, UBT]
* *N. kamerunensis* Schltr.	22	CAMEROON: Mt. Cameroon, NW Likombe	*Meve & Etuge 910* [B, K, MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Notechidnopsis* Lavranos & Bleck**			
* *N. tessellata* (Pillans) Lavranos & Bleck	22	R.S.A.: Northern Cape Prov., ca. 13 km N Nieuwoudtville, "Uithoek"	*Meve 255* [MSUN]
***Ophionella* Bruyns**			
# *O. arcuata* (N. E. Br.) Bruyns subsp. *arcuata*	22	R.S.A: Eastern Cape Prov.	*Bruyns 4966* [MSUN, UBT]
***Orbea* Haw.**			
O. irroata (Masson) L. C. Leach	22	s. loc.	*s. coll.*
# *O. longidens* (N. E. Br.) L. C. Leach	44	R.S.A: Kwazulu-Natal, Lower Mt. Kergl	*Hardy 6255*
# *O. miscella* (N. E. Br.) Meve	22	R.S.A.: Eastern Cape Prov., Richmond	*Bruyns 3237* [MSUN]
# *O. namaquensis* (N. E. Br.) L. C. Leach	22	R.S.A.: Northern Cape Prov., 4 km N Steinkopf	*Albers & Meve 111* [MSUN]
O. paradoxa (Verd.) L. C. Leach	44	s. loc.	*s. coll.* [MSUN]
O. rangeana (Dinter & A. Berger) L. C. Leach	22	NAMIBIA: 1 km N Klein Karas	*Albers 2356a* [MSUN]
# *O. semota* (N. E. Br.) L. C. Leach	44	TANZANIA: s. loc.	*Specks 921* [MSUN]
# *O. tapscottii* (Verd.) L. C. Leach	22	BOTSWANA: 15 km NW Molepolole	*Plowes 7829*
# *O. variegata* (L.) L. C. Leach	22	R.S.A.: Western Cape Prov., St. Helena Bay	*Bruyns 4571* [MSUN]
# *O. variegata* (L.) L. C. Leach	44	R.S.A.: Eastern Cape Prov., Stytlerville	*Albers 2466* [MSUN]
# *O. verrucosa* (N. E. Br.) L. C. Leach var. *verrucosa*	22	R.S.A.: Eastern Cape Prov., Grahamstown, Thomas Baines N. R. nr Damwall	*Liede 2919* [MSUN]
***Orbeopsis* L. C. Leach**			
# *O. albocastanea* (Marl.) L. C. Leach	22	NAMIBIA: s. loc.	*Bruyns 3045*
* *O. gerstneri* subsp. *elongata* (R. A. Dyer) L. C. Leach	22	R.S.A.: Mpumalanga, Pilgrim's Rest, Penge	*Hardy 4095*
O. gerstneri (Letty) L. C. Leach subsp. *gerstneri*	44	R.S.A.: Kwazulu-Natal, Empangeni	*de Kock sub Albers 2551* [MSUN]
# *O. lutea* (N. E. Br.) L. C. Leach subsp. *lutea*	22	R.S.A.: Northern Cape Prov., 15 km W Potchefstrom	*Albers 3525* [in hort. UBT]
# *O. lutea* (N. E. Br.) L. C. Leach subsp. *lutea*	22	ZIMBABWE: Bulawayo, Hyde Park	*Albers, Liede & Meve 537* [MSUN]
# *O. melanantha* (Schltr.) L. C. Leach	44	ZIMBABWE: Zambezi Valley, between Deka River & Binga River	*Plowes 6502*
O. tsumebensis (Oberm.) L. C. Leach	22	NAMIBIA: 5 km N Grootfontein	*Rawe s.n.* [MSUN]
* *O. valida* (N. E. Br.) L. C. Leach	22	ZIMBABWE: Wankie Distr., Kamativi	*Buckland s.n.*
***Orthanthera* Wight**			
# *O. albida* Schinz	22	NAMIBIA: near the Groot Welwitschia Vlakte	*Albers 2727* [MSUN]
***Pachycymbium* L. C. Leach**			
* *P. carnosum* (Stent) L. C. Leach	22	R.S.A.: Northern Cape Prov., Magaliesberg, Breedts Nek	*Hardy sub Plowes 6715* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Pectinaria* Haw.**			
# *P. longipes* (N. E. Br.) Bruyns	22	R.S.A.: Western Cape Prov., Keerom, Sutherland	*Bruyns 2548* [MSUN]
***Piaranthus* R. Br.**			
* *P. comptus* N. E. Br.	22	R.S.A.: Western Cape Prov., between Klaarstrom and Prince Albert	*Albers et al. 10708 in K 1123* [MSUN]
* *P. decorus* (Masson) N. E. Br. subsp. *decorus*	22	R.S.A.: Western Cape Prov., near Sterkfontein	*Bruyns 6290*
* *P. parvulus* N. E. Br.	22	R.S.A: Western Cape Prov., ca. 7 km SW Laingsburg (Witteberge)	*Meve 288* [MSUN]
***Pseudolithos* P. R. O. Bally**			
P. caput-viperae Lavranos	22	*ex hort.* Mesa Garden	*s.n.* [MSUN]
* *P. dodsonianus* (Lavranos) Bruyns & Meve	22	SOMALIA: 4 km NNW Erigavo	*Lavranos 7326* [MSUN]
***Quaqua* N. R. Br.**			
# *Q. acutiloba* (N. E. Br.) Bruyns	22	R.S.A.: Northern Cape Prov., 11 km N Concordia	*Meve 213* [MSUN]
Q. albersii Plowes	22	R.S.A: Western Cape Prov., bet. Vredendal and Holrivier to Liebendal	Albers 2252 [MSUN]
# *Q. cincta* (Lückh.) Bruyns	22	R.S.A.: Northern Cape Prov., N Concordia	*Pehlemann 2737* [MSUN]
# *Q. incarnata* subsp. *aurea* (Lückh.) Bruyns	22	R.S.A: Western Cape Prov., Pakhuis Pass	*Albers 2031b* [MSUN]
# *Q. incarnata* (L. f.) Bruyns subsp. *incarnata* var. *incarnata*	22	NAMIBIA: N Aus, branching off Helmeringhausen	*Albers & Meve 95* [MSUN]
Q. incarnata subsp. *incarnata* var. *tentaculata* Bruyns	22	R.S.A: Western Cape Prov., 40 km N Nieuwoudtville, Kokerboomkop	*Meve 246* [MSUN]
Q. inversa N. E. Br.	22	R.S.A: Western Cape Prov., Bitterfontein	*Bruyns 6133* [MSUN]
Q. linearis (N. E. Br.) Bruyns	22	R.S.A: Western Cape Prov., Spreenfontein	*Bruyns 2423* [MSUN]
# *Q. mammillaris* (L.) Bruyns	22	R.S.A: Western Cape Prov., 15 km S VanRhynsdorp	*Meve 146* [MSUN]
# *Q. marlothii* (N. E. Br.) Bruyns	22	R.S.A: Western Cape Prov., 1 km N Karoopoort	*Albers et al. K1415* [MSUN]
Q. multiflora N. E. Br.	22	R.S.A: Northern Cape Prov., Calvinia	*Bruyns 4297* [MSUN]
Q. parviflora (Masson) Bruyns subsp. *gracilis* (Lückh.) Bruyns	22	R.S.A: Western Cape Prov., below Gannaga Pass	*Bruyns 989* [MSUN]
Q. parviflora (Masson) Bruyns subsp. *pulchra* Bruyns	22	R.S.A: Western Cape Prov., between Vredendal and Holrivier	*Albers 2253*
Q. parviflora (Masson) Bruyns subsp. *swanepoelii* (Lavr.) Bruyns	22	R.S.A.: Northern Cape Prov., 30 km S Loerisfontein on road to Calvinia	*Lavranos s.n.* [MSUN]
Q. pillansii (N. E. Br.) Bruyns	22	R.S.A: Western Cape Prov., Montagu, Kogmanskloof	*EH 190 sub Albers 2553*
Q. pruinosa (Masson) Bruyns	22	s. loc.	*ex Kennedy sub Albers 2514* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
Q. ramosa (Masson) Bruyns	22	R.S.A: Western Cape Prov., SW Laingsburg	*Albers 2481* [MSUN]
***Rhytidocaulon* P. R. O. Bally**			
R. fulleri Lavranos & Mort.	22	OMAN: Dhofar, 56 km E Salalah	*Collenette 8439* [MSUN]
* *R. macrolobum* Lavranos subsp. *minumum* Meve & Collenette	22	SAUDI ARABIA: 60 km NW Najran	*Collenette 8792* [MSUN]
R. sheilae D. V. Field	22	SAUDI ARABIA: Muhayl	*Collenette 8964*
***Riocreuxia* Decne.**			
R. burchellii K. Schum.	22	R.S.A.: Kwazulu-Natal, s. loc.	*ex hort. Shirley* [MSUN]
***Stapelia* L.**			
# *S. asterias* Masson	22	R.S.A: Western Cape Prov., between Calitzdorp and Van-Wyksdorp	*Albers et al. 10726 in K 1136* [MSUN]
S. baylissii L. C. Leach	22	R.S.A.: Eastern Cape Prov., Zuurberg Pass	*Bayer s.n.* [MSUN]
S. erectiflora subsp. *prostratiflora* L. C. Leach	22	R.S.A: Western Cape Prov., Dornrivier Bridge	*Bruyns 1289* [NBG]
# *S. gigantea* N. E. Br.	22	MALAWI: Lake Malawi	*Albers 2575*
S. glanduliflora Masson	22	R.S.A: Western Cape Prov., 25 km S Klawer	*Albers & Meve 04* [MSUN]
# *S. grandiflora* Masson	22	LESOTHO: NW Mafeteng, Hermon	*Gerbaulet & Struck 23783* [MSUN]
# *S. hirsuta* L.	22	R.S.A: Western Cape Prov., Veldrif	*Albers 2498* [MSUN]
# *S. kwebensis* N. E. Br.	22	ZIMBABWE: Tuli, at Botswana border	*Albers 2568* [MSUN]
S. longipedicellata (A. Berger) N. E. Br.	22	NAMIBIA: W Khorixas	*Marschewski 114* [MSUN]
S. montana L. C. Leach var. *montana*	22	R.S.A: Western Cape Prov., Groot Winterhoekberge, near Pardevlei	*Bayer 1602* [MSUN, NBG]
# *S. pillansii* N. E. Br. var. *pillansii*	22	R.S.A: Western Cape Prov., S. Palmietfontein, "Jagerskraal"	*Meve 299*
S. remota R. A. Dyer	22	NAMIBIA: Baynes Mtns. (Kaokaoveld)	*Steenkamp sub Plowes 5146*
# *S. rufa* Masson	22	R.S.A: Western Cape Prov., 27 km S Laingsburg	*Albers 2483* [MSUN]
S. schinzii A. Berger & Schltr. var. *schinzii*	22	NAMIBIA: W Windhoek	*Pehlemann 445*
***Stapelianthus* Choux ex A. C. White & B. Sloane**			
S. arenarius Bosser & Morat	22	MADAGASCAR: N Tulear, Morombe road	*Teissier 111* [MSUN]
S. decaryi Choux	22	MADAGASCAR: Beloha direction to Tsihomb, 4 km from Tsiomb	*Liede, Conrad & Barad 2747* [MSUN]
S. hardyi Lavranos	22	MADAGASCAR: s. loc.	*ex hort. de Boer* [MSUN]
# *S. madagascariensis* (Choux) Choux	22	MADAGASCAR: Ambovombé direction to Antanimora, 15 km from Antanimora	*Liede, Conrad & Barad 2788* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
S. montagnacii (Boit.) Boit. & Bertrand	22	MADAGASCAR: s. loc.	*s.n.* [MSUN]
S. pilosus Lavranos & Hardy	22	MADAGASCAR: Amboasary (S)	*Mies & Nober 51b*
***Stapeliopsis* Pill. (= *Pectinaria* Haw. p.p.)**			
S. breviloba (R. A. Dyer) Bruyns	22	s. loc.	*ex hort. De Boer* [MSUN]
# *S. exasperata* (Bruyns) Bruyns	22	R.S.A.: Northern Cape Prov., Middlepos, Wolvedans	*Bruyns 4513* [MSUN]
# *S. pillansii* (N. E. Br.) Bruyns	22	R.S.A.: Eastern Cape Prov., Port Elizabeth, NW von Ann's Villa	*Bruyns 1561*
# *S. saxatilis* (N. E. Br.) Bruyns subsp. *saxatilis*	22	R.S.A.: Western Cape Prov., 19 km SE Oudtshoorn	*Meve 410* [MSUN]
***Tavaresia* Welw.**			
# *T. barklyi* (Dyer) N. E. Br.	22	NAMIBIA: Kaokoveld	*Albers 3599* [MSUN]
***Tridentea* Haw.**			
T. dwequensis (Lückh.) L. C. Leach	22	R.S.A.: Northern Cape Prov., 45 km ESE Brandvlei	*Karoo Garden 117/82* [MSUN]
# *T. gemmiflora* (Masson) Haw.	22	R.S.A.: Western Cape Prov., 13 km E Murraysburg	*Meve 348* [MSUN]
# *T. jucunda* var. *cincta* (Marl.) L. C. Leach	22	R.S.A.: Eastern Cape Prov., 15 km S Hutchinson	*Meve 349* [MSUN]
# *T. marientalensis* (Nel) Leach subsp. *albipilosa* (Giess) Leach	22	NAMIBIA: Karasburg, Farm Elandsdraai (WSW Ariamsvlei)	*Albers 2348* [MSUN]
# *T. pachyrrhiza* (Dinter) L. C. Leach	22	R.S.A.: Northern Cape Prov., Richtersveld, Oranjemund	*Hardy 4739*
T. parvipuncta var. *truncata* (Lückh.) L. C. Leach	22	R.S.A.: Western Cape Prov., Botterkloof Pass	*Vorster & Lavranos 2994* [MSUN]
T. virescens (N. E. Br.) L. C. Leach	22	R.S.A.: Northern Cape, N Brandvlei	*Lamberti s.n.* [in cult. UBT]
***Tromotriche* Haw.**			
# *T. aperta* (Masson) Sweet	22	R.S.A.: Richtersveld	*Visser sub Albers 2498* [MSUN]
# *T. baylissii* (L. C. Leach) Bruyns var. *baylissii*	22	R.S.A.: Eastern Cape Prov., Kouga Dam	*v. Jaarsveld 11057* [MSUN]
# *T. choanantha* (Lavranos & Hall) Bruyns	22	R.S.A.: Eastern Cape Prov., Kleinberg	*v. Jaarsveld 684/87* [MSUN]
# *T. longii* (Lückh.) Bruyns	22	R.S.A.: Eastern Cape Prov., 55 km SE Jansenville, Pardepoort	*Albers 2464* [MSUN]
* *T. longipes* (Lückh.) Bruyns	22	NAMIBIA: ca. 16 km N Rosh Pinah	*Albers & Meve 75* [MSUN]
# *T. revoluta* (Masson) Haw.	22+2B	R.S.A.: Western Cape Prov., 9 km S Botterkloof Pass	*Albers 2048a* [MSUN]
T. ruschiana (Dinter) Bruyns	22	*s. loc.*	*cult. J. Thompson*
***White-sloanea* Chiov.**			
W. crassa (N. E. Br.) Chiov.	22	SOMALIA: between Garawe and Gardo, Dan Garayo	*Lavranos & Barad s.n.*

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
Tribe: ASCLEPIADEAE (R. Br.) Duby			
Subtribe: Asclepiadinae Endl. ex Meisn.			
***Asclepias* L.**			
# *A. fascicularis* Decne.	22	U.S.A.: *ex hort.* Davis	*ex hort. Davis* [UBT]
A. flava N. E. Br.	22	ARGENTINA: San Pedro de Colalao (Tucumán)	*Liede 3096*
# *A. linaria* Cav.	22	MEXICO: Michoacán, 3 km NW Los Reyes and 25 km E Maravatio	*Conrad 9305* [MSUN]
A. tuberosa L.	22	U.S.A.: ex hort BG Michigan	*ex hort. BG Michigan*
***Calotropis* R. Br.**			
C. gigantea (L.) R. Br.	22	TANZANIA: Amboni	*Liede & Meve 3378* [UBT]
C. procera (Ait.) Ait. f.	22	KENYA: Rift Valley to Baringo, W Koriema	*Liede & Newton 3177*
***Gomphocarpus* R. Br.**			
G. cancellatus (Burm. f.) Bruyns	22	R.S.A.: Western Cape Prov., Rooinekpass	*Albers 3031* [MSUN]
G. filiformis (E. Mey.) Dietr.	22	NAMIBIA: near Groot Welwitschia Vlakte	*Albers 2726* [MSUN]
G. linearis D. Dieter	22	KENYA: Naivasha, Nakuru-Nairobi (Rift Valley)	*Liede 3180* [ULM]
G. tenuifolius (N. E. Br.) Bullock	22	ZIMABAWE: Mtoko	*Albers, Liede & Meve 511* [MSUN]
***Kanahia* R. Br.**			
K. laniflora (Forssk.) R. Br. s.l.	22	KENYA: Teita, Sala Gate, (Tsavo East)	*Liede & Newton 3211* [E, MSUN, ULM]
K. laniflora (Forssk.) R. Br. s. str.	22	YEMEN: North	*Mangelsdorff Y116* [UBT]
***Pergularia* L.**			
# *P. daemia* (Forssk.) Chiov. var. *daemia*	22	CAMEROON: Rhumsiki, centre of village	*Meve 920* [MSUN]
# *P. daemia* (Forssk.) Chiov. var. *daemia*	22	TANZANIA: Moshi, Rau-Forest	*Liede & Meve 3367* [UBT]
P. daemia (Forssk.) Chiov. var. *macrantha* Chiov.	22	KENYA: 56 km W Malindi	*Liede & Newton 3209* [ULM]
P. gariepensis N. E. Br.	22	R.S.A.: Northern Cape Prov., Richtersveld	*Albers 3579* [MSUN]
P. tomentosa L.	22	YEMEN: 10 km W Madinet as Sharq	*Mangelsdorff Y213* [UBT]
***Stathmostelma* K. Schum.**			
S. diversifolia Goyder	22	KENYA: Narok, ca. 32.2 km on Kikorok Road, Loita Plains	*Liede & Newton 3221* [K]
***Stenostelma* Schltr.**			
S. capense Schltr.	22	R.S.A.: Eastern Cape Prov., Teviot Stn.	*Liede 2934* [K, MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
Subtribe: Astephaninae Endl. ex Meisn.			
***Microloma* R. Br.**			
* *M. incanum* Decne.	20	NAMIBIA: 5 km N Aus	*Albers & Meve 88* [MSUN]
* *M. sagittatum* (L.) R. Br.	20	R.S.A.: Western Cape Prov., 22 km N Matjiesfontein	*Meve 376a*
* *M. tenuifolium* (L.) K. Schum.	20	R.S.A.: Western Cape, Kapokberg	*Meve & Liede 623* [MSUN]
Subtribe: Glossonematinae K. Schum.			
***Glossonema* Decne.**			
G. boveanum (Decne.) Decne. ssp. *boveanum*	22	KENYA: ca. 30 km from Loyengalami	*Liede & Newton 3239* [UBT, ULM]
***Pentarrhinum* E. Mey.**			
# *P. insipidum* E. Mey.	22	R.S.A.: Gauteng, Irene-Verwoerdburg	*Liede 2941* [MSUN]
P. insipidum E. Mey.	24	KENYA: Isiolo	*Liede & Newton 3225*
Subtribe: Gonolobinae (G. Don) Liede			
***Fischeria* DC.**			
F. sp.	22	COSTA RICA: Region Guana Caste, Cabo Blanco	*Voigt s.n.* [in cult. UBT]
***Gonolobus* Michx.**			
G. barbatus HBK	22	MEXICO: Jalisco, 2 km NE Tequila	*Conrad 9325* [UBT]
***Macroscepis* Kunth**			
M.sp. (near urceolata Karst.)	22	GUATEMALA: 60 km N Guatemala-City	*Heyne s.n.* [UBT]
***Matelea* Aubl.**			
M. carolinensis (Jacq.) R. E. Woodson	22	U.S.A.: Georgia, Athens	*Lipow s.n.*
M. cyclophylla (Standl.) R. E. Woodson	22	MEXICO: s. loc.	*ex hort. G. Barad*
Subtribe: Metastelminae Endl. ex Meisn.			
***Blepharodon* Decne.**			
B. salicinum Decne.	22	ECUADOR: betw. Estación Scientifica San Francisco and Zamora	*Liede 3304* [ULM]
***Cynanchum* L.**			
C. abyssinicum Decne.	22	TANZANIA: Arusha Prov., Olmoti Crater	*Liede & Meve 3373* [UBT]
C. ampanihense Jum. & H. Perrier	22	MADAGASCAR: Cap St. Marie	*Liede 2817a* [MSUN]
C. andringitrense Choux	22	MADAGASCAR: s. loc.	*Rauh s.n.* [MSUN]
C. angavokeliense Choux	22	MADAGASCAR: s. loc.	*s.n. ex Specks* [MSUN]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
C. appendiculatopsis Liede	22	MADAGASCAR: s. loc.	*Fervier s.n.* [MSUN]
C. arenarium Jum. & H. Perrier	22	MADAGASCAR: Tuléar, 15 km to Antanimora	*Liede 2789*
C. auriculatum Royle ex Wight	22	BHUTAN: Pass from Thimpu to Wangduephodrang	*Liede 3281* [MSUN]
C. bisinuatum Jum. & H. Perrier	22	MADAGASCAR: Toliara	*Decoings 28283* [UBT]
C. boerhaviifolium Hook. & Arn.	22	CHILE: ca. 2 km N Los Vilos	*Liede 3062*
C. compactum Rauh	22	MADAGASCAR: Fiananrantsoa, ca. 42 km W Ambatofinadrahana	*Supthut & v. Arx 3029*
C. cucullatum N. E. Br.	22	MADAGASCAR: Ankaratra	*Liede 2868* [MSUN]
C. descoingsii Rauh	22	MADAGASCAR: Tuléar	*Descoings 28244*
C. erythranthum Jum. & H. Perrier	22	MADAGASCAR: Ankarana	*Mangelsdorff M 26*
C. danguyanum Choux	22	MADAGASCAR: Maintirano	*Mangelsdorff 44* [UBT]
C. formosum N. E. Br.	22	CHILE: Los Vilos, ca. 2 km from town	*Liede & Conrad 3061* [MSUN, UBT]
# *C. gerradii* (Harv.) Liede	22	KENYA: 30 km N Maralal	*Meve 962* [MSUN]
C. gerradii (Harv.) Liede	22	MADAGASCAR: betw. Ambovombé and Antanimora, sidetrack to Angavo	*Liede 2797* [MSUN]
# *C. hardyi* Liede & Meve	22	MADAGASCAR: Ankarafansika	*Mangelsdorff M37*
C. implicatum Jum. & H. Perrier	22	MADAGASCAR: Montagne des Francais	*Mangelsdorff 24*
C. juliani-marnieri Descoings	22	MADAGASCAR: Cap St. Marie	*ex hort. Les Cèdres* [MSUN]
C. laeve Pers.	22	U.S.A.: Missouri, St. Louis, near Shaw Arboretum	*Liede s.n.* [UBT]
C. lecomtei Choux	22	MADAGASCAR: Cap St. Marie	*Liede 2817b* [MSUN]
C. leucanthum K. Schum. subsp. *elongatum* Liede	22	MADAGASCAR: 48 km W Samabava	*Mangelsdorff 410* [UBT]
C. madagascariense K. Schum.	22	MADAGASCAR: forest 43 km from Ft. Dauphin	*Liede 2756* [MSUN]
C. marnieranum Rauh	22	MADAGASCAR: 43 km from Ambovombé direction to Tsihombé	*Liede 2805* [MSUN]
C. messeri (Buchenau) Jum. & H. Perrier	22	MADAGASCAR: between Beloha and Ampanihy, 5 km from Beloha	*Liede 2831*
# *C. mevei* Liede	22	MADAGASCAR: Tulear, S de la Table	*Teissier 214* [MSUN]
C. montevidensis Spreng.	22	ARGENTINA: Chaco, Isla del Cerrito	*Liede & Conrad 3019a* [ULM]
C. nodosum (Jum. & H. Perrier) Descoings	22	MADAGASCAR: 15 km from Antanimora to Ambovombé	*Liede 2789*
C. nummulariifolium Hook & Arn.	22	ARGENTINA: Las Lenas, Valle de las Moches	*Liede 3050* [ULM]
C. obovatum (Decne.) Choux	22	MADAGASCAR: ca. 7 km from Ambalamanakana (to Ambosita)	*Liede 2866* [MSUN]
# *C. obtusifolium* L. f.	22	R.S.A.: Eastern Cape Prov., Misfor	*Liede 2925* [UBT]
C. ovalifolium Wight	22	AUSTRALIA: ca. 1.5 km upstream Brown crossing, rd. to Lockhart River Misn.	*Forster 4090*

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
C. papillatum Choux	22	MADAGASCAR: Andringitra	*Liede & Conrad 2862* [MSUN]
C. perrieri Choux	22	MADAGASCAR: s. loc.	*Descoings 28283*
# *C. petignatii* Liede & Rauh	22	MADAGASCAR: Tuléar	*Teissier 269* [UBT]
C. phillipsonianum Liede & Meve	22	MADAGASCAR: Ankarana, Tsingy	*Mangelsdorff M 25* [MSUN]
C. rauhianum Descoings	22	MADAGASCAR: Isalo	*Röösli s.n.*
C. repandum Decne.	22	MADAGASCAR: Ankaratra	*Liede 2867* [MSUN]
C. rossii Rauh	22	MADAGASCAR: Cap St. Marie	*Singer O72478* [MSUN, ZSS]
C. serpyllifolium Kunth	22	ECUADOR: Carachi, El Angel-Tulcan road at Pico Aquer	*Bremer et al. 3372* [MSUN, UPS]
C. sessiliflorum (Decne.) Liede	22	MADAGASCAR: 15 km from Windsor Castle	*Mangelsdorff 13* [MSUN]
***Folotsia* Costantin & Bois**			
F. grandiflora Jum. & H. Perrier	22	MADAGASCAR: Ambovombé to Antanimora, km 24 on sidetrack to Angavo	*Liede 2796* [ULM]
***Funastrum* E. Fourn.**			
F. angustissimum (Anderss.) E. Fourn.	20	ECUADOR: Galapagos Islands, s. loc.	*Stevens s.n.*
F. arenarium (Decne. ex Benth.) Liede	20	MEXICO: San Carlos, road to Beach (Baja California)	*Liede & Conrad 2951* [MSUN, ULM]
F. bilobum (Hook. & Arn.) Macbride	20	MEXICO: Chiapas, La Trinitaria	*Stevens 25744*
F. clausum (Jacq.) Schultes	20	U.S.A.: Florida, Everglades, Reclamation site John Strekl Park	*Liede 3000*
F. crispum (Benth.) Schltr.	44	U.S.A.: Texas, Hueco Tanks State Park	*Liede & Meve 2504* [MO]
# *F. cynanchoides* (Decne.) Schltr. subsp. *cynanchoides*	20	MEXICO: Todos Santos, Sierra Laguna trail (Baja California)	*Liede & Conrad 2958*
F. odoratum (Hemsl.) Schltr.	20	GUATEMALA: Guatemala City, Mixto, Fritz Richter's House	*Liede 3244* [UBT]
***Grisebachiella* Lorentz**			
G. hieronymi Lorentz	20	ARGENTINA: 3 km to Las Moches from Las Lenas (Mendoza)	*Liede & Conrad 3053* [MSUN, ULM]
***Karimbolea* Desc.**			
# *K. macrantha* (Jum. & H. Perrier) Liede & Meve	22	MADAGASCAR: Cap Ste. Marie, 150–200 m from lighthouse along road	*Liede 2829*
***Metaplexis* R. Br.**			
# *M. japonica* (Thunb.) Makino	22, 24	RUSSIA: Primorsk Region	*ex hort. Tartu* [UBT, ULM]
***Metastelma* R. Br.**			
M. parviflorum R. Br.	22	VENEZUELA: Tocopéro	*Liede & Meve 3329* [ULM]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Orthosia* Decne.**			
O. rubens (L. Wms.) Liede ined.	20	MEXICO: Los Azufres, ± 15 km NW of Ciudad Hidalgo	*Conrad 9396* [MSUN, UBT]
O. sp.	20	ECUADOR: Quito	*Liede & Meve 3473* [UBT]
***Oxystelma* R. Br.**			
O. bornouense R. Br.	22	KENYA: Coast, ex hort.	*Liede & Newton 3202* [ULM]
O. esculentum R. Br.	22	EGYPT: Elephantine Island	*Shirley s.n.*
***Pentacyphus* Schltr.**			
P. lehmannii (Schltr.) Liede	22	ECUADOR: Loja, Yananga	*Liede 3333* [UBT]
***Philibertia* Knuth**			
* *P. gilliesii* Lillo	18	ARGENTINA: Mendoza, La Crucecita, ca. 1.5 km from intersection	*Liede 3054* [MSUN]
P. gilliesii Lillo	20	ARGENTINA: Jujuy, Laguna de Yala	*Liede 3111*
P. lysimachioides (Wedd.) T. Meyer	20	BOLIVIA: La Paz, Copacabana peninsula, 8 km from San Pedro	*Liede 3139* [MSUN]
***Platykeleba* N. E. Br.**			
P. insignis N. E. Br.	22	MADAGASCAR: Antanarivo	*Rauh 68500*
***Sarcostemma* R. Br.**			
# *S. acidum* (Roxb.) Voigt	22	NEPAL: NE Dharapani, near Bheri River	*Bruyns s.n.*
# *S. antsiranense* Meve & Liede	22	MADAGASCAR: 75 km N Sambava	*Mangelsdorff 47* [UBT]
# *S. arabicum* Bruyns & P. I. Forst.	22	YEMEN: SW Sana'a	*Radcliffe-Smith 4624* [K]
S. brevipedicellatum P. I. Forst.	22	AUSTRALIA: Gregory North Distr. (Qld.), 86 km from Winton on Boulia Road	*Forster 5876*
* *S. forskaolianum* Schult.	22	YEMEN: 78 km S Dhamar, near branching off Zulmah on Sumarah-Ibb Road	*Noltee 864*
# *S. pearsonii* N. E. Br.	22	R.S.A.: Northern Cape Prov., Smorenskadu	*Liede 2523* [MSUN]
S. resiliens B. R. Adams & R. W. K. Holland	22	ZIMBABWE: 15 km NNW of Rusape	*Albers, Liede & Meve 515* [MSUN]
# *S. stoloniferum* Adams & Holland	44	KENYA: Rumuruti, Kisima Ranch	*Liede & Newton 3174* [MSUN]
S. viminale (L.) R. Br. subsp. *australe* (R. Br.) P. I. Forst.	22	AUSTRALIA: Telowie Gorge (SA)	*Meve & Hellbrügge 723* [MSUN]
S. viminale subsp. *brunonianum* (Wight & Arn.) P. I. Forst.	22	AUSTRALIA: S Kennedy Distr. (Qld.), Thomas Is., NW shore	*Bolton 700* [MSUN]
S. viminale subsp. *brunonianum* (Wight & Arn.) P. I. Forst.	22	YEMEN: Suq As Sabt, Jabal Bura	Wood *3431* [K]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
# *S. viminale* subsp. *odontolepis* (Balf. f.) Meve & Liede	22	KENYA: Kilifi, Arabuko, Sokoke forest	*Field & Powys 186* [MSUN]
* *S. viminale* subsp. *orangeanum* Meve & Liede	22	NAMIBIA: Steinhausen, S Gobabis	*Meve & Liede 599* [MSUN]
* *S. viminale* subsp. *thunbergii* (Don) Liede & Meve	44	R.S.A.: Western Cape Prov., Atties, 1.5 km S Wiedow's River	*Liede & Hammer 2507*
# *S. viminale* subsp. *stipitaceum* (Forssk.) Meve & Liede	22	YEMEN: 1 km E Al Barh	*Noltee 233* [MSUN]
# *S. viminale* (L.) R. Br. subsp. *viminale*	22	MADAGASCAR: between Ampanihy and Androka, 73 km from Ampanihy	*Liede 2701*
***Schizostephanus* Hochst. ex Benth. & Hook. f.**			
S. alatus Hochst. ex K. Schum.	22	KENYA: Kilifi, Chasimba Hills	*Keneally 9478*
Subtribe: Oxypetalinae K. Schum.			
***Amblystigma* Benth.**			
A. cionophorum Fourn.	22	ARGENTINA: Yerba Buena (Tucumán)	*Liede 3069*
***Araujia* Brot.**			
A. angustifolia Steud.	20	ARGENTINA: Hurlingham, English Club	*Liede 3014* [UBT, ULM]
A. hortorum E. Fourn.	22	ARGENTINA: Buenos Aires, Avenida San Martin	*Liede 3010*
T. brunonis Hook. & Arn.	40	ARGENTINA: Mendoza, Godoy Cruz	*Liede 3058* [ULM]
***Morrenia* Lindl.**			
M. odorata Lindl.	22	ARGENTINA: Chaco, Resistencia	*Liede 3020* [ULM]
***Oxypetalum* R. Br.**			
O. balansae Malme	18	ARGENTINA: Mendoza, Campground "El Challoa"	*Liede & Conrad 3059* [MSUN]
O. coeruleum (D. Don) Decne.	28	ARGENTINA: s. loc.	*ex hort.* [MSUN]
O. ostenii Malme	22	ARGENTINA: Iguacu, Sendero Macuru	*Liede 3042* [MSUN]
O. solanoides Hook. & Arn.	18	ARGENTINA: Buenos Aires, I.N.T.A. area	*Liede & Conrad 3011* [ULM]
***Tweedia* Hook. & Arn.**			
T. brunonis Hook. & Arn.	40	ARGENTINA: Mendoza, Godoy Cruz la Ripiera	*Liede & Conrad 3058* [UBT, ULM]
Subtribe: Tylophorinae (K. Schum.) Liede			
***Blyttia* Arn.**			
B. fruticulosa (Decne.) D. V. Field	22	KENYA: A.I.C. Chemolingot Bore Hole	*Liede 2946* [MSUN]
***Diplostigma* K. Schum.**			
D. canescens K. Schum.	22	TANZANIA: S Pare Mts., NE Mkomazi	*Liede & Meve 3388* [UBT]

Appendix 1. Continued.

Taxon	2*n*	Locality	Voucher
***Pentatropis* R. Br. ex Wight & Arn.**			
P. madagascariensis Decne.	22	MADAGASCAR: 4 km from Tsiomb. between Beloha and Tsihomb	*Liede 2749* [P, UBT]
P. nivalis (J. F. Gmel.) D. V. Field & J. F. Wood	22	KENYA: near Hell's Kitchen	*Meve 949* [MSUN, UBT]
***Pleurostelma* K. Schum.**			
P. cernuum (Decne.) Bullock	22	TANZANIA: W Tanga	*Liede & Meve 3377* [UBT]
***Tylophora* R. Br.**			
T. apiculata K. Schum.	22	KENYA: Tana River Distr. Hewani Forest	*Robertson & Guffa 6894* [MSUN]
T. barbata R. Br.	22	AUSTRALIA: 2 km S Kioloa (NSW)	*Meve & Hellbrügge 790* [MSUN]
T. coriacea Marais	44	MAURITIUS: Isle Rinde	*Bernadi s.n.* [BR, UBT]
T. flexuosa R. Br.	22	PHILIPPINES: Laguna/Quezon, ascent to Mt. Banahaw	*Schneidt & Liede 96-31* [K, ULM]
T. heterophylla N. E. Br.	22	KENYA: Naivasha, Aberdares, 5 km before junction	*Liede 3155* [MSUN, ULM]
T. hirsuta (Burm. f.) Merr.	22	INDIA: Allahabad	*Chaturvedi s.n.* [MSUN]
# *T. indica* (M. Burm.) Merr.	22	INDIA: s. loc.	*Bruyns s.n.* [MSUN]
T. oblonga N. E. Br.	22	CAMEROON: Mt. Cameroon, NW Likombe	*Meve 915* [B, MSUN]
T. perrottetiana Decne.	22	PHILIPPINES: Los Banos, IRRI-Ground	*Liede 3252* [MSUN]
T. tenuipedunculata K. Schum.	22	KENYA: Arabuko Sokoke Forest	*Liede 3200* [MSUN]
T. villosa Blume	22	PHILIPPINES: Luzon, Alaminos	*Schneidt & Liede 96-109* [AUH]
***Vincetoxicum* Wolf**			
# *V. hirundinaria* Medik. ssp. *hirundinaria*	22	F.R.G.: Thüringen, Kyffhäuser-Mountains	*Albers 3646* [MSUN]

SUBTRIBE ASTEPHANINAE (APOCYNACEAE–ASCLEPIADOIDEAE) RECONSIDERED: NEW EVIDENCE BASED ON cpDNA SPACERS[1]

Sigrid Liede[2]

Abstract

The circumscription of the subtribe Astephaninae has a complex and convoluted history due in part to a scarcity of readily observed distinctive morphological characters. In this study the subtribe Astephaninae, as hitherto defined by morphological characters, is reexamined using sequences of the *trn*T-L and *trn*L-F spacer, as well as the *trn*L intron for 12 of its 15 genera. *Eustegia* is found to occupy an isolated basal position in the tribe Asclepiadeae, and *Schizostephanus* is transferred to the Metastelminae. The remaining 10 genera fall into two only distantly related clades of 3 and 7 genera, respectively. The Astephaninae s. str. comprise only 3 South African genera, *Astephanus* s. str., *Microloma*, and *Oncinema*. The other 7 genera form a well-supported clade, the subtribe Tylophorinae. Both groups comprise only Old World genera. All New World taxa studied, even those that have never been formally excluded from *Astephanus*, are found in a distinct, well-supported New World Metastelminae clade. Based on the results presented here one of the key characters of the asclepiads—the corona—has been lost independently at least twice: once in the south African Astephaninae, and once in the New World Metastelminae. This once again underscores the extreme lability of this morphologically complex organ, as well as the difficulties in assessing homology in the asclepiads. A corollary classification of the Asclepiadeae is provided as an Appendix.

Key words: Apocynaceae–Asclepiadoideae, Astephaninae, *trn*L intron, *trn*T-L and *trn*L-F spacer.

The tribe Asclepiadeae, morphologically characterized by pendent pollinia and the possession of true styles (Swarupanandan et al., 1996), forms a monophyletic group occupying an advanced position in the Apocynaceae s.l. according to recent molecular studies (Sennblad, 1997; Civeyrel et al., 1998). The relationships among the ca. 100 Asclepiadeae genera, however, are much less clear. Schumann (1895) distinguished five subtribes using exclusively corona characters. In an attempt to define subtribes on a broader range of apomorphic characters Liede (1997) also recognized five groups, but with a largely different composition. As a sixth subtribe, she added the Gonolobinae following Swarupanandan et al. (1996).

The subtribe Astephaninae Endl. ex Meisn. (1840) originally contained only three genera: *Astephanus* R. Br., *Haemax* E. Mey. (a synonym of *Astephanus*), and *Hybanthera* Endl. (a synonym of *Tylophora* R. Br.). Schumann (1895) considered the subtribe to comprise nine genera: *Microloma* R. Br. from southern Africa, *Adelostemma* Hook. f., and *Henrya* Hemsl. (another synonym of *Tylophora*) from Asia, as well as *Amblystigma* Benth., *Esmeraldia* E. Fourn. (a synonym of *Metastelma* R. Br.), *Hemipogon* Decne., *Mitostigma* Decne., and *Nautonia* Decne. all from South America. *Astephanus*, founded by Brown (1810) exclusively on southern African material and regarded by him as a close relative of *Microloma* (Brown, 1810), was soon extended to contain American taxa without a corona. However, since the absence of a feature—in this case the corona—is not meaningful as an indication of relationship, both the circumscription of the subtribe Astephaninae and of the genus *Astephanus* were in need of reexamination.

Most experts now agree that *Astephanus* s. str. is restricted to the Old World and comprises only three species (*A. marginatus* Schltr., *A. neglectus* Schltr., and *A. triflorus* R. Br.) as stated in Liede (1994). Most of the New World members formerly included in the genus *Astephanus* have been interpreted meanwhile as species with a reduced corona within various currently recognized genera with

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